AMATEUR RADIO 73

#128
May 1971
One Dollar

- 75 m Mobile Antenna
- 10 m DSB Transmitter
- 450 MHz "Remote" Transmitter
- Transistor LM Freq Meter
- 2m FET Preamp

73 MAGAZINE

#128 May 1971

Contents

FEATURES

STAFF

73 Magazine is published monthly by 73 Inc , Peterborough, New Hampshire 03458. Subscription rates are $6 for one year in North America and U.S. Zip Code areas overseas, $7 per year elsewhere. Two years $11 in U.S. and $12 overseas. Three years $15, and $16 overseas. Second class postage paid at Peterborough, N.H. and at additional mailing offices. Printed at Menasha, Wisconsin 54952 U.S.A. Entire contents copyright 1971 by 73 Inc., Peterborough NH 03458. Phone: 603-924-3873. We don't wish to cause any alarm, but reports of great disasters have been coming in from 73 readers who have permitted their subscriptions to lapse. Why take chances?

On the Cover:

DLØSTA, Germany's first 2m FM repeater atop Stuttgart's famous Fernsehturm.

Amateur Radio News Page

April MCMLXXI | Monthly Ham News of the World | 73 Magazine

FCC PROPOSES NEW EXPANDED PHONE BANDS

The FCC has just released its long-awaited proposal to expand the high-frequency phone bands. The move came after many long months of poring over petitions, proposals, and comments submitted by interested amateurs and groups. The petition, if passed without change, would mark the amateur's first move into a licensing system that is truly based on "incentive" rather than "punishment."

FCC Secretary Ben Waple said, "The Commission believes that some expansion of the . . . telephony subbands is desirable." He stated that an exclusive 25 kHz segment of each phone band would be set aside at the low end for Extra class use. In justifying this, he added, "The modest number of U.S. licensees of this class should not significantly affect foreign telephony operation therein and the greater possibility of . . . (working DX) should be an incentive to qualify for the Extra class license.

With the exception of the 7 MHz band, expansion of each of the current Extra/Advanced reserved subbands is proposed. Expansion of current General/Conditional subbands is proposed in four bands. Expansion of the 28 MHz phone subband to provide a similar pattern of Extra and Extra/Advanced phone subbands is also being proposed by the Commission. Appropriate modification of the 7 and 21 MHz Novice subbands is included. A 28 MHz Novice band is being proposed as compensation for the proposed reduction in the 21 MHz Novice spectrum. Because of the light occupancy in the current 25 kHz

General and Conditional: All authorized amateur privileges except those exclusive frequency operating privileges which are reserved to the Advanced or Extra class but including operating privileges in the 7075–7100 kHz band with telegraphy, and with telephony when located outside Region 2.

Novice: Those amateur privileges designated and limited as follows:

Radiotelegraphy is authorized in the frequency bands 3700–3750, 7100–7150 (7050–7075 when located outside Region 2), 21100–21200 and 18150–28250 kHz, using only type A1 emission and 145–147 MHz, using radiotelegraphy emissions as set forth in § 97.61.

Amateur Extra and Advanced: All authorized amateur privileges including exclusive frequency operating authority in accordance with the following table:

Frequencies	Class of license authorized
3500-3510 kHz	
3750-3775	
7000-7010	
7150-7175	Amateur Extra Only
14000-14010	
14150-14175	
21000-21010	
21200-21225	
28350-28375	
3775-3875 kHz	
7075-7100	
7175-7225	
14175-14250	Amateur Extra and Advanced
21225-21325	
28375-18500	
50.0 - 50.1 MHz	

Pacific Coast Hams Get Shifted

Parts 2 and 97 of the Rules dealing with the sharing of the 1800–2000 kHz band by the amateur radio service has been amended by the Commission to modify the availability of the frequencies for use by the amateur service on a shared basis with Loran stations. The action becomes effective April 13, 1971.

The Commission action was in response to notice from the Coast Guard that certain changes in the Loran-A radionavigation system are necessary for implementation by May 1, 1971.

Parts 2 and 97 permit the amateur service to use the band on the basis that it shall not cause interference to the Loran-A radionavigation service, that it shall not be a bar to the expansion of Loran, and is "subject to cancellation or to revision, in whole or in part, by order of the Commission without hearing . . . "

The changes provide modifications in the Pacific Coast frequency segments to shift amateur operation from the higher frequency segments to the lower frequency segments.

LED Crystal Growth Development

Experimental gallium-phospide crystals have been grown for the first time at Motorola in Phoenix. Such crystals are the starting material for the fabrication of green light emitting diodes. A modified Czochralski technique is used to "pull" the crystals from a molten alloy of the two elements. High ambient pressure ($\approx$ 1500 lb/in²) is required over the melt in order to compensate for the unequal vapor pressures of gallium and phosphorous. Without pressure, the phosphorous would rapidly boil off, and no useful crystals would be formed. The high pressure reaction chamber is housed inside a 10 ft diameter safety tank, and growth of crystals is monitored remotely on a TV screen. Establishing a high volume capability in the production of exotic materials such as gallium phosphide is a necessary part of Motorola's continuing expansion in the field of optoelectronics.

ANTIQUE WIRELESS and RADIO DISPLAY

A fine exhibit of antique wireless and radio equipment is on display at the Aerospace Museum, Balboa Park, San Diego, California. The members of the San Diego Chapter of QCWA, under the chairmanship of Jim Barth

W6KCO, have installed this unique display which should be of interest to the general public and educational for the many school children who visit this fine museum. Things of interest include a display of early radio tubes from land, sea and aircraft equipment and a model 1920 wireless station.

Hunger Hikes Need Hams' Help

On May 8 and 9, 1971, in more than 350 cities in the U.S. and 40 others around the world, millions of private citizens will be walking through their local communities in the certified record of the miles they walked.

In every Walk there is need for a communications network, preferably mobile, that keeps track of the Walk

Extra class CW segments, the FCC stated, reduction of each of these allocations to 10 kHz is proposed.

The specific rule changes proposed by the FCC are as follows:

Authorized frequencies and emissions

Frequency band, MHz	Emissions
1.800-2.000	A1, A3
3.500-4.000	A1
3.500-3.750	F1
3.750-3.875	A5, F5
3.750-4.000	A3, F3
7.000-7.300	A1
7.000-7.075	F1
7.075-7.100	A3, F3, Ab, F5
7.100-7.150	F1
7.150-7.225	A5, F5
7.150-7.300	A3, F3
14.000-14.350	A1
14.000-14.150	F1
14.150-14.250	A5, F5
14.150-14.350	A3, F3
21.00-21.45	A1
21.00-21.20	F1
21.200-21.325	A5, F5
21.20-21.45	A3, F3
28.00-29.70	A1
28.00-28.35	F1
28.35-29.70	A3, F3, A5, F5

SPECTRUM STUDY PLANNED

According to a recent article in *Electronics*, the FCC and the White House Office of Telecommunications Policy are about to disclose detailed plans for a study of the use of the radio spectrum. In preparation for the study, OTP has already asked the Interdepartment Radio Advisory Committee to prepare a statement on the nature and extent of the government's use of the spectrum. Since large blocks of frequencies are set aside for exclusive government use, the consensus is that the committee's statement could lead to provisions for nondefense agencies to share their frequencies with private users. The study is a part of a long-term program that should "lead to a more rational use of the frequency spectrum."

Radio Comes to Aid of Girl

Reprinted from Dallas Times Herald.

An emergency call from South America answered by a Dallas ham radio operator may save the life of a small Colombian girl.

"I feel she will be okay here in Dallas," said the mother of 8-year-old Monica Rosada who will soon be operated on in Dallas for a serious liver ailment.

Monica who may need a liver shunt operation checked into Children's Medical Center Tuesday after a 22,000-mile diagnosis.

It all began Sunday when ham radio operator John Adel intercepted a call for help from Barranquilla, Colombia. Monica was crticially ill and losing blood.

Her mother, Mrs. Mariela Rosada wanted to bring her to the United States for the needed operation.

"I was afraid to make the operation there," said Mrs. Rosada, "I was afraid of post operation. And somebody told me there was a good hospital here."

Thanks to Adel and medical personnel in the United States and Colombia, Monica arrived in Dallas Tuesday and had doctors and a hospital bed waiting at the Children's Medical Center.

Monicas family doctor sought a ham radio operator in the Dallas area to see if he could get in touch with a Colombia doctor he thought was in Dallas.

"Another ham radio operator called me Sunday," Adel said, "and asked me to help him with this call for help from Colombia. We took the call and got in touch with the doctor after finding out he was practicing in Wichita Falls now."

Then the ham radio operator got the two doctors together. They diagnosed the girl and decided she needed to be hospitalized immediately.

The Wichita Falls doctor then contacted another Colombia doctor in Dallas for him to make the necessary arrangements for Monica at Children's Center.

Dr. Carlos Esquiva, from a town only 100 miles away from the little girl's hometown made the arrangements. Dr. Esquiva, a resident at St. Paul Hospital, also was on hand to meet the youngster's airplane.

APOLLO LAUNCH PARTICIPATION WANING

The Cape Kennedy Amateur Radio Society conducted its special launch for the Apollo 14 mission on January 31, 1971, despite attrition of its members due to a layoff occurring at the Space Center. Approximately 500 calls were handled by the club members.

Founded about five years ago, the Space Center Amateur Radio Society at one point had as many as 40 members. At present the society is down to 8 members. During previous launch operations, as high as 2000 calls have been taken in the 24 hours following the launch. The peak was reached during the Apollo 11 launch. During the Apollo 12 launch they received approximately 1300 calls, about 900 were recorded for Apollo 13, and at this time about 500 calls for the Apollo 14 mission.

The reduction in the calls was not due to the number of amateurs attempting to contact the club station, WB4ICJ, but rather due to the fact that the club was down to only two transmitters on 20 and 40 meters, and the fact that they were reduced to four operators plus a visiting amateur who assisted.

largest constructive show of grassroots concern about the problems of hunger and poverty that the world has ever witnessed. In conjunction with the U.N. Food and Agriculture Organization (FAO), the American Freedom from Hunger Foundation (AFFHF) is sponsoring the International Walk for Development Weekend through the local organizing activities of its student Young World Development committees. Effective radio communications both within and among the individual Walks is essential for the safety and success of all the Walks. Hams nationwide are being asked to participate on the local level in this world-wide effort.

The Walk for Development is a program proven around the nation during the past five years in its capacity to raise funds for foreign and domestic self-help development projects. Moreoever, it is a good means to motivate a whole community into learning and doing more about the catastrophic problem that the malnourishment of one-half the world graphically represents. Whole communities are drawn together to co-operate in the effort, and, in the process, generation and apathy gaps are bridged.

A Walk works like this: a local group organizes itself to conduct a public information campaign – giving speeches, printing posters, distributing brochures – and to recruit Walkers. The local committee also maps out a Walk route – usually 20 to 30 miles long – that winds through the city or countryside. Each Walker is responsibile for soliciting his own sponsors, each of whom pledges to contribute an amount of money – from a few cents up to a dollar or more – for every mile successfully completed by the Walker. On the day of the Walk, the crowd of Walkers begins early in the morning on its trek, hiking throughout the day; then they collect from their sponsors according to a along the route and handles all the traffic that deals in emergency and organizational information as well as information on food and medical supplies. Such a situation would probably be most effectively handled by a radio network of 2 meter FM mobile and based rigs in conjunction with a repeater. Where these are lacking, one could also use nets of 6m or 40m mobile rigs.

Beyond the individual Walk networks, there is another dimension to consider. A feeling of common effort is present among all those around the world taking part in that day; in a sense, however, the realization of this fact is largely limited to paper. Communications between the participants, both in the U.S. and in the rest of the world would really create a live experience of international unity, and allow the walkers to sense the dimensions of their present efforts and their future tasks. It would greatly enhance the Walks to have national and international radio communications between different Walks, and between the Walks and the projects they are supporting. People could exchange words of thanks and good will, send messages on the progress and outcome of certain Walks and sense a unity of common action.

In order to facilitate such a venture, it might be helpful for hams just to be listening to their sets when they have free time the weekend of May 8-9. From that net frequencies, controls and timetables will evolve as needed.

If you or your club are interested in helping out and wish more information about the Walks in your area, please contact Mike Donoghue, Maryknoll College, Glen Ellyn, Illinois 60137, (312) 469-4500, or Mary Ann Mason of the American Freedom from Hunger Foundation, 1717 H St., N.W., Washington, D.C. 20006, (202) 382-6727.

HAMFESTS and PICNICS

The Yellow Thunder Hamfest 71 will be held at the Dellview Hotel in Lake Delton, Wisconsin on May 23, 1971. Afternoon programs will include MARS, WATS ARPSC and others with a banquet in the evening. Tickets are $5 in advance or $5.75 at the door. For further information contact Kenneth A. Ebneter, K9GSC, 822 Wauona Trail, Portage, Wisconsin 53901.

The Wabash Co. ARC's third annual hamfest will be Sunday, May 23, rain or shine, at the Wabash Co. 4H fairgrounds. There will be activities for all including Bingo, Flea Market (no setup charge), repeater talks, film and slides, and an amateur television talk with demonstration. Food will be available. Admission is $1. For more information write Bob Mitting, 663 N. Spring St., Wabash, Indiana 46992.

38th ANNUAL WESTERN NEW YORK HAMFEST & VHF CONFERENCE, Rochester, New York, May 15th. Activities start Friday night followed by full day of programming with outstanding speakers. An added feature is the huge flea market covering an area of 6 acres. New location is Monroe County Fairgrounds on Rte. 15A near Thruway Exit 46. Send for map and program. Registration $2.75, Advance Dinner/registration $6.75 before May 10. Mail check to: R.A.R.A., Box 1388, Rochester, N.Y. 14603.

The 17th annual Breeze Shooters Hamfest will be held at White Swan Park, Parkway West near the Greater Pittsburgh Airport on May 23. This is the "largest" amateur event in the Western Pennsylvania area so plan to attend. Plenty of free parking, large amusement park for the XYL and harmonics. Talk-in frequency is 29.00 and 146.94. For additional details write D. J. Myslewski, K3CHD, 45 McMahon Drive, Irwin, Pa. 15642.

(winner takes pick). Bring your equipment to swap and auction (bring your own tables, pls). Pre-registration $1.00, regular admission $1.25. Pre-registration send to (or for more information): Art Hartwell, 2630 El Segundo Dr., Rancho Cordova, Calif. 95670. (916) 363-9225. Pre-registration deadline 8 May 1971. Playground area for children at park.

After an absence of several years, the Malden Amateur Radio Auction returns, sponsored by the Malden Amateur Radio Assn. This auction has always been one of the biggest and best in New England and now it will be bigger and better than ever.

The place – Same place, the American Legion hall on Pleasant St., Malden, Mass.

The time – Same time, eight o'clock in the evening.

The date – Saturday, May 22, 1971.

Terms – Same terms, we get 10%.

Refreshments of course. There will be the usual surprises and awards. Come early for a good seat. Please, we will not accept any floor sweep-ins. We reserve the right to limit the items of any one person. Tag and identify all your equipment. Low pressure auctioneer. Eli Nannis W1HKG.

The Birminghamfest this year will be on May 2 at the Armory on Oporto Avenue (just off U.S. 78 East – near Eastwood Mall). For entertainment, prizes, contests, net meetings, eyeball QSO's and fun for the entire family, plan to attend. For further information contact the Birmingham Amateur Radio Club – W4CUE, Box 603, Birmingham, Alabama 35201.

The Baton Rouge Amateur Radio Club will again hold their annual hamfest in Baton Rouge, Louisiana on the first weekend in May.

The festivities will start with a hospitality room Saturday afternoon at 1:00 p.m. at the Holiday Inn-

70th ANNIVERSARY OF OLD "CC" TO BE OBSERVED BY W-1-SS

The year 1971 marks the 70th anniversary of the start of construction of the old "CC" – the original Marconi station on Cape Cod, Massachusetts, where the first wireless messages between England and the United States were exchanged by President Teddy Roosevelt and King Edward VII of England.

Those stations desiring to work the site of the original Marconi station will find W-1-SS active on all bands from 160 Meters through 2 Meters during the DX hours for each band on the last weekend in April. Look for W-1-SS the Club Station of the Bedford Massachusetts Radio Club on April 24, 1971 and April 25, 1971.

Band	CW	Phone
160	1.801	1.805 MHz
80	3.580	3.935 MHz
40	7.100	7.260 MHz
20	14.050	14.315 MHz
15	21.100	21.375 MHz
10	28.100	28.700 MHz
6		50.200 MHz
2		145.100 MHz

Hey! Hey! Eligibility Period For Extra to be Cut

Reduction of the eligibility period for the amateur Extra class operator license from two years to one year has been proposed by the FCC in a rule making notice. The proposal would amend Part 97 of FCC rules (licensing and operating requirements for the Amateur Extra Class License). The FCC also proposed that holders of the amateur "Extra, First Class" license, issued between June 1923 and June 1933, receive credit for the 20 wpm code requirements needed to qualify for the present Extra class license.

OPERATION OILY BOID

In the foggy predawn hours of the morning, two oil tankers (one inbound, one outbound) collided near the Golden Gate Bridge creating one of the largest oil spills in recent years. In excess of 800,000 gallons of bunker fuel seeped out of the ruptured forward section of one of the tankers. The crude-like oil was rapidly carried into San Francisco bay by the incoming tide. Later, as salvage operations began, the tidal action went to work on the oil and reports soon came in that oil had spread along the bay waterfront in San Francisco, Sausalito, the Tiburon peninsula and Angel island. The outgoing tide carried the oil out to sea but evidence of the spill was appearing both north and south of the Golden Gate bridge at coastal beaches. As tidal action and ocean currents spread the oil to an ever widening area, reports were received that local water birds were in trouble. School children and residents were finding oil-soaked birds on beaches and taking them to the Richardson Bay Audubon Sanctuary for treatment.

The next day, bird salvage operations were in full swing at the sanctuary on the Tiburon peninsula and oil-soaked birds were being received in large numbers. Before long, local radio and TV stations were broadcasting requests for volunteers to assist in the bird-washing operation. Volunteers responded by the hundreds and soon bird-washing and treatment centers were established at Bolinas Lagoon, Richmond, Terra Linda and the San Francisco zoo in addition to Audubon headquarters in Tiburon. It looked like the birds had a chance and the concerned people of the Bay Area were working around the clock on "Operation Oily Boid."

As more and more volunteers appeared to help, it soon became evident that the already jammed


NON CARBORUNDUM BUSTIS

For Gallantry in Action & Services Above & Beyond the Call of Duty on the days from January 19 to January 23, 1971,

-YOU-

73 MAGAZINE – WAYNE & KEN

ARE HEREBY AWARDED

'The Order of the Dirty Bird'

AND ACCORDINGLY WILL RECEIVE ALL PRIVILEGES & HONORS THEREOF.

YOU WILL BE ACKNOWLEDGED BY ALL MANKIND AS BEING

'For the Birds'

SEAL AND SIGNATURE AFFIXED BY MY HAND ON THIS DAY FEBRUARY 1st IN THE YEAR OF 1971

T.C. Nelson PRESIDENT WB6AAE

Chas J. Beck PRESIDENT K6GWE

SECRETARY

PRESIDENT WB6FCY

expand and man the communications network.

Basic operation and traffic handling was coordinated on WB6AAE via the repeater. Additional coordination and organizational traffic handling was coordinated via WB6AAE's UHF repeater to allow 2 meters to handle only *Oily Boid* traffic. The coastal area in and around the bay is quite rugged and mountainous and although WB6AAE covers the area well, there were areas where communication was marginal. To overcome this terrain problem, the VHF Expeditionary Society activiated their own 2 meter repeater (K6GWE) and the two repeaters were tied together via a "human link." Stations on WB6AAE (2 meter FM), WB6AAE (UHF-FM), and K6GWE (2 meter FM) were set up at net control. Backup base stations were established in Oakland, San Francisco, and San Rafael to provide additional access to clear phone lines and handle overflow traffic.

In all, 65 amateurs from the three clubs spent a total of 922 hours providing FM communications during

The Fox River Radio League will have its annual Hamfest on August 15 at Phillips Park in Aurora, Illinois. Free coffee and donuts will be served from 9:00–10:00 AM. Advance tickets $1.00, $1.50 at the gate. Talk in frequencies 146.94 MHz and 3.94 MHz. For further information contact: Tom Rogers, WA9WBV, Box 323, Oswego, Illinois 60543.

Sacramento Valley annual ham get-together. Swap Shop – Eyeball QSOs. Sunday 15 May '71 – Carmichael Park. A joint presentation of the North Hills ARC, Sacramento ARC and the Rams. Visit the gang you rag-chew with and meet other hams. Special events for Novices and Old-Timers. Have your mobile rig and antenna analyzed by the RAMS. North Hills club will troubleshoot your equipment. Food and Refreshments – Coffee, hot dogs, soft drinks, suds, cookies, cake, etc. Two noted speakers: Oliver Swan and "Doc" Gmelin. Commercial exhibits and drawings every hour. Grand Prize: 3 el. beam or VHF beam -South followed by a supper and dance at the same location.

Sunday, May 2nd, a barbecue lunch, along with swap tables, auctioning, and raffling of door prizes will be held at the United Commercial Travelers Camp one mile east of Baton Rouge on Highway 190. The top door prize will be an SB-220 linear amplifier.

Each year that the event is held in Baton Rouge the attendance and activities grow larger and better. At last year's hamfest approximately 800 hams plus their families and friends attended.

EIA 220 MHz Proposal Filed

The Electronics Industry Assn filed its 220 MHz proposal with the FCC in mid-February for the establishment of a new Class E citizens band in what has been an amateur band heretofore.

The details on the proposal appeared in the March 73 editorial on newspage six and pages 124-125-126 of the same issue. Where the 73 proposal for the band is based upon keeping it as an amateur band with the addition of a new Hobby class of license permitted to use the middle part of the band, the EIA proposal calls for moving all amateurs out of their proposed CB segment.

Considering the financial clout of the EIA, their Washington lobby, and the lack of any power in Washington by amateurs, we will be very lucky not to permanently lose substantial parts of this band.

ARMED FORCES DAY 1971 WA9DZL

On Saturday, May 15, 1971, WA9DZL, amateur station of the 128th Air Refueling Group (TAC), Wisconsin Air National Guard will again place radio equipment on the ham bands in conjunction with Armed Forces Day. A very attractive commemorative Armed Forces Day certificate will again be mailed to all hams who contact WA9DZL during this special 3rd annual operation. The operating schedule is as follows:

14.295 MHz, ± 5 KHz – 1300 hrs GMT thru 2100 hrs GMT

7.280 MHz, ± 5 KHz – 1300 hrs GMT thru 1730 hrs GMT

28.780 MHz, ± 5 KHz – 1730 hrs GMT thru 2100 hrs GMT

146.940 MHzFM – 1300 hrs GMT thru 2100 hrs GMT (Monitoring)

To qualify for a certificate a two-way contact with WA9DZL, an FHC member, and your QSL card are the only requirements. All QSL cards are to be sent to WA9DZL, 128th Air Refueling Group (TAC), General Mitchell ANG Base, Milwaukee, Wisconsin 53207.

The Extra class license was established in 1952 as a new class indicative of the highest level of achievement available, and a comparison of the present day and former examinations indicates the new license examination is more difficult. However, since the 20 word-per-minute requirement remains the same in comparison to the earlier requirement, the Commission has proposed that licensees receive credit for the 20 word-per-minute requirement if they have held an amateur Extra First Class license and have continued, without interruption, to hold the succeeding Advanced class license.

The eligibility period for the Extra class license would be reduced from two years to one year in order to sustain licensee interest by permitting rapid upward movement in rank.

Navy Station Active for AFCEA

On-the-air ham radio facilities will be provided by the Navy's Washington voice in the amateur radio fraternity, K4NAA, operating daily from the Sheraton Park Hotel in Washington, D.C. during the three days of the Armed Forces Communication and Electronics Association Convention in June. AFCEA convention delegates with amateur radio licenses are invited to take advantage of the Navy's ham radio station to contact friends during the convention on June 8, 9, and 10.

The K4NAA fixed portable station will be operational from 0900 to 2200 EDST with two available positions for CW and SSB on the 10, 15, 20, 40, and 80 meter bands.

A specially designed QSL card has been prepared to acknowledge contacts with licensed amateurs throughout the world who are invited to make contact during the AFCEA convention.

The Navy and AFCEA invite all amateur radio enthusiasts to visit K4NAA on June 8, 9, and 10.

phone lines would not be able to handle the traffic necessary to coordinate an operation of this magnitude. Since the telephone numbers had been put out via the commercial broadcast sources, calls were coming in with offers of assistance and supplies so fast it was impossible to get a line for any kind of call out.

One of the volunteers who responded to the initial TV request for workers was also a ham who immediately saw the need for some sort of communication link to supplement the already jammed phone lines. Bob, WA6CZJ, is a member of the Grizzly Peak Radio Club which owns, operates and maintains a 2 meter FM repeater in the East Bay Area and provides excellent coverage to the Tiburon peninsula and the greater San Francisco Bay Area. Bob immediately set up a station at the Audubon headquarters and started operating through repeater WB6AAE on 2 meter FM. As operations expanded, Bob requested additional operators and equipment and within hours a complete emergency network was established with 9 base stations in operation at the strategic bird collection and treatment centers. Almost immediately the network became the backbone of the entire operation; not only did the hams provide an efficient system for traffic and message handling but a "conference net" was available when key officials wanted to confer on problems concerning the total operation. (This feature was to prove most important in later hours.)

As Operation Oily Boid progressed, more and more operators were required and more equipment was needed. Again the hams came through and a complete orderly communications link was manned by volunteers who came from over 100 miles away to lend equipment and time to help the birds. Word spread to other amateurs in the area and soon members of the VHF Expeditionary Society and the Pioneer Radio Club were working to Operation Oily Boid. In addition, the hams logged over 3000 miles patrolling beaches and shorelines during the five-day period the operation was conducted.

In retrospect, the entire operation was virtually interference-free through the repeaters, which were used simultaneously on two sets of frequencies. VHF FM provided clear channel operation where both CB and the HF bands would have been faced with interference and QRM emanating from outside the Bay Area. The use of the repeaters also allowed instant communications to be established through the use of hand-held mobile equipment working through the repeaters. "We would get a request for communications and immediately dispatch either a mobile or portable unit to the location to operate until a base station could be established and equipment delivered to the scene," said Tom Nelson (W6QGN), President of the Grizzly Peak Club. In fact, one operator worked mobile through K6GWE from Agate Beach for 12 hours, which provided the Audubon officials with an ear in an area which was virtually without any form of communications.

In all, *Oily Boid* was a success and thousands of birds were saved through the efforts of hundreds of volunteers who worked around the clock. But equally important were the efforts of the hams who helped by being there when they were needed to provide a service to the community.

The hams who participated actively will receive a special *Order of the Dirty Bird* certificate as a memento of the many long cold hours they spent operating "strictly for the birds."

...de W2NSD/1

EDITORIAL BY WAYNE GREEN

Assuming that my idea is all wet that amateurs can be encouraged to move up in license grade by the rewards of a distinctive call and that a highly structured and rigidly government controlled set of subbands is the answer, the recent FCC docket may be the ticket. Proponents of punitive licensing will, I suspect, be opposed to the very idea of offering rewards to those who get their higher licenses, preferring the system that punishes those who don't. Well, I've hit that gong enough for the last eight years and I'll let it be.

Your comments on the proposed changes in the phone bands should be in the hands of the FCC by June 1, with the usual 14 copies, if you can manage it. Perhaps, before you commit yourself to paper, some serious soul searching and objective (if possible) thinking will help you sort out not only what you personally feel about the new bands, but what you feel their impact on the future of the hobby may be.

While most of the new phone subbands are to be created from what were known as foreign phone bands previous to the development of sideband, a few of them will cut into CW bands or otherwise discommode present U.S. amateur use of the frequencies. I might point out that most of the foreign phone activity takes place within the U.S. phone band segments these days and that an expansion of our phone bands will have far less impact upon DX operators Street NW, Washington, D.C. 20554, know your considered opinion.

2m Airborne?

We just might be able to make it officially possible to operate on 2 meter FM from commercial planes. The catch is that we must have laboratory proof that our rigs are free from spurious emissions, particularly in the 108–118 MHz range. Perhaps there is a reader who is working with a recognized lab who could run such tests on presently available hand units by Motorola, GE, etc.?

Retirement for Wayne?

My amateur radio writing career started back in 1951 when I first published a bulletin for RTTY operators. This grew to over 200 circulation and ended when I became editor of CQ in January 1955. CQ and I parted in January 1960 and the first issue of 73 was in October 1960. Now, eleven years later, and after 20 years of editing and publishing for hams, I am beginning to think in terms of some sort of retirement . . . perhaps in two or three years or so.

It struck me that there might be an amateur out there somewhere with the business experience needed to run the magazine – who might be interested in 73. We have a fine staff and we are, in spite of the depression, operating in the black. 73 could, if run on a noncontroversial basis, make a very nice profit, probably picking up many more advertisers such as Collins,

German Repeaters

On the cover this month is the world-famous Fernsehturm, a needle-like tower jutting high in the sky over Stuttgart, Germany. At the top is a restaurant, a viewing room and a tower full of antennas. Most of the antennas, of course, are commercial types, radiating radio and TV signals throughout the countryside for miles around. But among the important commercial and industrial antennas are two insignificant quarter-wave omnidirectional radiators for 2 meters: the transmitting and receiving antennas for DLØSTA, one of Germany's first 2 meter repeaters.

The DLØSTA repeater inputs on 144.46 and outputs on 145.75 MHz. The radius of coverage of the Stuttgart machine is approximately 75 miles.

Other European repeaters currently in operation are these:

Call	Location	Input	Output
DLØJMA	Bayreuth	144.15	145.85
DLØCH	Cham	144.15	145.85
DLØUCA	Coburg	144.15	145.85
DJ9CRA	Cuxhafen	144.15	145.85
DKØRM	Frankfurt	144.15	145.85
DJ4JIA	Goslar	144.15	145.85
DLØBGA	Braunschweig	144 80	145.89
DJ3JWA	Lindau/Harz	144.15	145.85
DLØBLB	Ludwigsburg	144.85	145.30
DLØNFA	Nurnberg	144.15	145.85
DBØWZ	Wurzburg	144.15	145.85
DLØZU	Zugspitze	144.15	145.85
	Heidelberg	144.15	145.85
DLØZR	Schwerte	145.15	145.90

The frequencies noted in the above list are not permanent, according to a recent report from DL9GS. He says the consensus of opinion among German FM amateur radio operators is that the license authority will publish a new frequency allocation plan along with some rules governing repeater operation in Germany. The new requirement is expected to place all repeater inputs on 144.15 or 144.20,

the FM scene

by K6MVH

With the sudden burst of popularity of FM, all ham journals are carrying more material on the subject. Both CQ and Ham Radio have regular contributors they call "FM editors." Ham Radio's FM man is Jay O'Brien (W6GJO), an active and technically competent amateur who seems to be right up there in the forefront of the FM action. I have evaluated a number of O'Brien's technical manuscripts and have found them accurate, relatively up-to-date, and generally instructive.

But watch out for the CQ FM man, Glen Zook (K9STH). Zook's technical recommendations are often ill-advised and unsound. In the March issue of CQ, for example, Zook recommends use of Motorola "44" series 450 MHz equipment for repeaters – which is all right – but he suggests using the type with the "passive" front end rather than the superior "active" type.

The older Motorola 450 receivers used a pair of 6J4s in the front end which, in combination with Motorola's high-Q tuned circuits, offered excellent sensitivity and practically unmatched selectivity. With the advent of semiconductors, Motorola switched to a diode/cavity front end, which held up nicely as far as sensitivity was concerned but fell flat in the selectivity area. As a consequence, Motorola retained the "active" 6J4 front end for its repeaters, and used the "passive" units for ordinary bases and mobiles. Motorola made the right decision; the diodes just couldn't compete, selectivity-wise, with the 6J4s. If you have a choice, ignore Zook and grab the active-front-end receiver for your repeater.

town could produce so many amateurs in one place at one time. An even bigger surprise was the number of active FM operators; it looks like some 70% of the hams in the Midland area are also 2m FM operators. Needless to say, the FM portion of the meeting racked up the biggest attendance records.

There was a slight sour note. During my talk, I wanted everything to be informal, so I invited members of the audience to break in at any time with questions or comments. Roy Allbright, the local ARRL director, did. He seized the opportunity to lash out at 73 for profiteering, and pointed out that the League is a nonprofit organization dedicated to serving the needs of amateur radio in general. He didn't believe me when I told him that QST turns a better profit than all the other ham journals combined. He also made a few caustic remarks about Wayne Green.

Now, I expect League advocates to badmouth 73; after all, we at 73 continue to be a thorn in the side of the ARRL as long as we don't concur 100% with what they do up there in Newington. But I've had it up to here with people who make snide comments about Wayne. In most cases the fellows who make their little vitriolic statements have never met Wayne. They don't know him except from what they read in his editorials.

The fact is, Wayne Green is the most dedicated amateur I've ever met. He puts ham radio before business. To the detriment of 73, he will speak out on issues that are predestined to make him unpopular – all for the sake of amateur radio. Wayne has the kind of today than it would have in the old AM phone days.

Think it over carefully. Talk it over. Argue about it. You might even try arguing both sides, if you can handle that type of thing. When you're done sit down and let the FCC, 1919 M Eimac, Millen, etc., and a lot more subscribers. It should not be difficult to increase our present small profit by well over $100,000 a year, if this sort of thing is of any great importance.

Anyone with the background and wherewithal out there?

and all outputs on 145.75 or 145.80 MHz.

In Switzerland, only 450 MHz repeaters are allowed. And there have been no repeaters reported for Holland, Belgium, or Luxembourg. However, according to information supplied by DL9GS, there are a few Austrian repeaters using the 144.15/145.85 MHz pair.

Zook also shows control circuits operated from 115V ac. *Don't you be foolish enough to use 115V for your control functions* – it's just not worth it! Primary 115V power on open relays is dangerous, for one thing. For another, high-voltage ac relays are expensive – often unobtainable on the surplus market. But, most important, a flock of relays and wires with a 115V, 60 Hz signal on them, is an introduction to problems of "hum and buzz" another nemesis to the well-designed repeater. The first-class way to go for control switching is 24–28V, and all dc.

Please forgive me for being negative. FM rates the biggest push we can give it, and the more said in the amateur journals, the better. Read the FM columns by all means. But keep a wary eye peeled. I know whereof I speak.

On Hamfests and Such. . .

I just returned from a very successful hamfest in Midland, Texas. The big surprise was that this relatively small

integrity that makes him speak his mind regardless of the consequences, which are often unfavorable businesswise.

When Wayne should be working, he is frequently in the hamshack making DX contacts. When he should be devoting time to his family, he'll often devote it to hamming on his 2m FM walkie-talkie. Then, late at night, when everyone else has gone to bed, he'll get stricken with a belated attack of conscience and slip into his office to make up the work he's missed during the day.

And that's not all. Wayne is a good human being. Equally affable with heads of state or factory workers, he is a friend to anyone who offers friendship. And, what is most important of all to me, he is MY friend – which makes me deeply resentful of uninformed upstarts who get up before audiences and make statements that are untruthful, unfounded, and just plain stupid.

Dayton Hamvention, April 24

Don't dare miss the Dayton Hamvention this year; it looks better than ever. The program will be leaning heavily toward the FM field, in recognition of the intense interest being devoted in this area during recent months. GE's Paul Perrone (K4CYJ) will be demonstrating his company's unique receiver voting system, which should give aspiring repeater owners some food for thought.

The Miami Valley FM Association will operate talk-in services on a continuous basis on Friday and Saturday (April 23 and 24). The talk-in frequency will be 146.94 MHz, simplex. Repeaters in the area that can be keyed from mobiles in the vicinity of the Hamvention will be operating on the following pairs: 146.34/146.76, 146.46/146.88, 146.22/146.82. A 6 meter simplex station will also be manned on 52.525 MHz.

The Hamvention boys have set up a hospitality room at the Imperial House North Motel – this affair gets under way Friday night at 9.

ou goons don't ever proofr

LETTERS

I insist that you print ev

I am reading with great interest and enjoying 73 tremendously. I always look forward to the new issue.

Hussein
THE ROYAL PALACE,
Amman, Jordan

Not much organized activity yet. But check the page of national FM standards, April issue, for 220 MHz frequencies. Articles are in the works.

. . .Ken

Layout – Pro

I haven't commented on it before but your new layout is the best in the business in my opinion. Also appreciate your variety. I wonder how that other mag from New England can make it in this business as narrow and pseudo-sophisticated as it is.

Joseph T. Taylor K5PAC

FM

For some time I have been contemplating the idea of getting on 220 MHz. Since FM is the only way to go, I was wondering if there is any activity of this nature at this time. I would like information as to national calling frequencies and established repeater frequencies. Also, I would like to see information in 73 on conversion or construction of equipment for this purpose.

George E. Jones WB4AQR
5803 12th Street
Tampa FL 33604

I wish to thank you for the VHF FM articles in your magazine. They are enjoyed by all the hams here at WWNC radio. Can you tell me the FM repeater frequencies in use in the six-state area surrounding western North Carolina? This information would be useful to me because of our altitude and interference problems. In the very near future we will have a repeater going and will let you know the frequency decided on.

Glen A. Bell,III
WWNC
Asheville NC 28802

Check repeater directory, April issue, as well as article on intermod problems. Should help.

. . .Ken

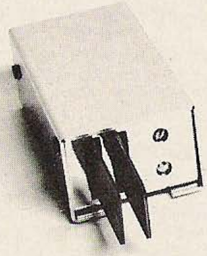
Goodwill Hams

I was pleased to read W7SCU's letter in the January issue about his purchases at the local Goodwill Industries store. There are over 143 local and autonomous Goodwill Industries' throughout the United States. Each unit has on an average of five retail outlets in which very interesting and unusual merchandise is available.

The sale of this merchandise thru our retail outlets helps to make payrolls for handicapped people. Our philosophy in the Goodwill Industries Movement is "A Change, Not Charity."

(continued on News Page Four)

NEW PRODUCT



A new deluxe key from James Research, packaged in a polished chrome plated steel cabinet, measures only 1 9/16" high by 2 1/4" wide by 3 3/4" deep and weighs 14 ounces total. The completely enclosed permaflex mechanism has independent fiberglass paddles which flex to make contact and have adjustable gap and tension. Additional feet allow the key to be used on its side as a straight hand key. The 8-ampere gold diffused contacts will key a transmitter directly or the low level inputs of an IC keyer. Included with the key is an internal bracket and blank printed circuit board to permit home brewing a keyer or other circuit. Pre-punched 1/4" diameter front panel holes will accommodate standard and imported subminiature switches and potentiometers.

The key is 100% US-made by James Research and is guaranteed for one year. The key is available by direct mail only for $24.95 postpaid. This includes parcel post shipping and insurance in the United States. For further information contact James Research Company, Department AR-D, 20 Willits Road, Glen Cove, NY 11542.

(continued from News Page Three)

At Goodwill Industries of Central Pennsylvania in Harrisburg, we have started Novice classes for handicapped people.

73 is a fine magazine!!

Lowell W. Carter WA3NXR
Executive Vice President
Goodwill Industries of Central Pennsylvania, Inc.
P. O. Box 3327
Harrisburg PA 17105

Fine Print

I note with interest (in March letters) W6VVF's comments concerning his reading the fine print in your excellent magazine. As an optometrist, I can sympathize, both with tongue in cheek and seriously. I am 45 and very much require my bifocals for all close work. Even I pulled out the bar magnifier to read page 24 listing the FCC petitions.

I am sure you have many partial-sighted readers. I am equally sure they have great difficulty reading segments of your magazine.

In answer to W6VVF, I promise you, Mr. Nichols, we optometrists have no conspiracy going. Prevention of visual problems is very much our concern.

J. H. Robinson, O.D. (WØRJZ)
218 W. Montgomery
Creston IA 50801

Keep up the good work. I still enjoy the magazine very much. I have only one *small* criticism. Please do not print the first few pages on their sides. It makes it awfully hard to read. The small print is bad enough, at least print the pages right side up.

Robert Z. Muggli WN9CVX
17938 Homewood Ave.
Homewood IL 60430

As a subscriber from the very beginning I'd like to put in a vote against a repitition of that monstrosity you put in for an index in the Dec. 1970 issue. It is as near unreadable as you can get, or I thought so until I saw some of the minia-

I would appreciate it if you could explain the "management" of them, specifically answer the following general questions. I'm sure others have been wondering about the same thing.

Who owns a typical repeater?

Who paid for its construction?

Who performs required maintenance?

Who pays the electric bill?

Who is responsible in case they cause injury or other damage (e.g. start a fire)?

Can anyone (with proper equipment) use one?

If I were to use one would I need permission from the owner? Would I have to contribute to its upkeep?

What motivation is behind their establishment? (Especially if they are not a "money making" venture)

Are there any special restrictions on the "operators" who use them?

Who owns the property they are located on?

How are they protected from unauthorized tampering or vandalism?

Perhaps you could answer some of these questions in an editorial or "Leaky Lines" column of 73 if you feel this subject needs further discussion.

John J. Risch WØFEV
7135 Farley Ave.
St. Louis MO 63121

Let's take your questions one at a time.

1. Who owns a typical repeater?

Say a few of the fellows who operate on one of the local FM frequencies decide it would be a good idea to get increased range and more reliable coverage. So they get together and make a decision to put up a repeater. They form a club and get as many people into it as they think their repeater will accommodate without crowding. Each club member is expected to pay dues and contribute materially to the repeater's development. Then, as a group, they apply for a repeater license and begin construction on a joint basis.

the job of a kilowatt.

9. Are there special restrictions for repeater users?

Sometimes; it depends on the club and its members.

10. Who owns the property?

Clever hams find property in various ways. Some rent from the state or federal government, while others contact land-owners who have choice high locations.

11. How are they protected from vandalism or tampering?

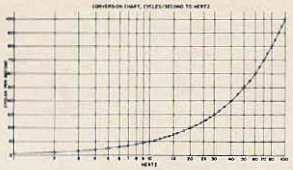
All kinds of clever ways. Some people install repeaters in locked buildings, and others install them on vulnerable power poles. Still others are stashed in garages, shacks, or bedrooms. But protecting the repeaters becomes a fun-type challenge that should appeal to all true experimenters. Intercom arrangements, for example, can be incorporated into a system so that if an intruder is in the vicinity, the repeater comes on and all sound in the area of the repeater is relayed to the control point on the UHF or wireline control link. The repeater owner can then note whether or not the intrusion is a bonafide burglary, and notify the local authorities if necessary. He would also have the capability of shutting the system down if the alarm turned out to be spurious.

All of these questions and others are answered in depth in "Radio Amateur's FM Repeater Handbook," Editors and Engineers, Ltd., Indianapolis IN 46268 ($6.95). And if you are interested in repeaters from a lay point of view, why not send for a copy of "An Introduction to Amateur FM," available from 73 Magazine ($1.50).

. . . Ken

Phone Patches

A couple of comments on W4NVK's article in the February 73, *Phone Patch Level Adjustments and Manproofing*: His otherwise fine article makes one bad statement, and that is that he recommends the use of



up to the minute in state-of-the-art understanding of electronics.

Douglas H. Horner
1260 E Ave.
Marion IA 52302

Plaudits

Thanks very much for your fine magazine, and your late better format, with editorials, ham news, etc. clear across the page, and not continued in back of magazine – much easier to read. Keep up the fine work, and all the best.

Chester M. Benson W9IFB
732 So. 14th St.
Richmond IN 47374

I owe you an apology for not writing long ago and telling you how pleased I have been with the results of my modest advertising in 73 Magazine. Other than QST, my only written advertising has been in 73 since 1966 when I first introduced my new TRANSKEY electronic keyer. I can say that your magazine is nearly totally responsible for establishing my entire sales program for the keyer . . . and this includes sales in foreign countries where buyers have seen your ads.

I agree with your philosophy concerning the best of hobbies, ham radio, and will continue to do all I can to interest young people in ham radio. I will also continue to boost our hobby before my friends in Washington, D.C.

Howard Furst W6PHA
P.O. Box 246
El Toro CA 96230

Snowfall

All of us at Mount Snow appreciate the excellent article, *To the Repeater*

Bet he'll not forget again that Circuit-Stik is available from Circuit Specialists, Box 3047, Scottsdale AZ 85052.

Ouch!

Somebody should put a *bleeder* of some sort across the power supply, page 41 (March 1971). 16 ηF of "oils" will hold a 1.3 kV charge too long . . .

Neil Johnson W2OLV
74 Pine Tree
Tappan NY

Right on!

Real Dedication

I was both surprised and delighted to receive your check as payment for the materials that I forwarded to you concerning the late R. V. L. Hartley (May 1971). Your policy of paying well and promptly for all materials that appear in 73 Magazine is aptly confirmed.

However, I am unable to accept payment for the material. It was submitted for publication out of respect and friendship for Ralph Hartley, who, as you know, was an Honorary Member of the New Providence Amateur Radio Club. Nor could the Club accept payment for the material. Publication in 73 as our tribute to Mr. Hartley is more than enough reward for us.

I suggest therefore that you use the money to purchase a good article on some subject of interest to all amateurs for publication in 73. Dissemination of useful information in this fashion would be in keeping with Ralph Hartley's admiration for amateurs. Although not licensed himself, he truly appreciated that way in which amateurs consistently demonstrated the applicability of many of his ideas long prior to their commercial acceptance. I'm sure he would have approved.

Alfred E. Hirsch, Jr. K2SKV
33 Evergreen Rd.
Summit NJ 07901

turized printing in the last issue. What gives?

John C. Carroll WA6YTR
155 E. County Line Rd.
Calimesa CA 92320

Why the sidewise print on so many pages? Why the small print? How many can read the Wayne Green petition on page 124 in the March issue? If it's worth printing then it should be printed in large enough type so that it doesn't take a magnifying glass to read!

Jos. P. Fincutter K3STU
5620 Alta Vista Rd.
Bethesda MD 20034

I used to enjoy your news pages but in Feb. I needed a magnifying glass to read it. There is no excuse for using print smaller than the telephone book. It was just too much effort to finish reading it.

Marv W4SPQ
6209 Thornwood Dr.
Alexandria VA 22310

Wild One

Can you give me a lead on some VHF FM equipment? I'll go insane trying to figure this thing out without a schematic! It's 3 pieces of Westinghouse equipment: power supply, transmitter, & receiver. Each is approximately 8 in. wide, 6 in. high & 18 in. deep.

Power Supply (Style 1473613A)

Transmitter (Style 14770034D) [2-6146's]

Receiver (Style 1477038K)

Can anyone steer me toward the address of Westinghouse or anyone else who might be able to sell, rent, or loan me a schematic?

Bruce Tiemann WB2RUH
304 Laurel Ave.
Woodlynne NJ 08107

Any takers?

Repeaters

I have read many articles regarding repeaters. However I failed to find one which explained the logistics or economics of them. Perhaps I did not read the right articles.

2. Who pays?

The dues should pay for just about everything the repeater will involve: and if the dues do not cover an expenditure, the club's board of directors will most likely assess club members for an additional amount, depending upon whether or not such an expenditure is upheld by popular vote within the club.

3. Who performs the required maintenance?

Most repeaters have one or two individuals who like the technical end more than the communicating end. These are the folk who get the maintenance jobs. Usually, as compensation for their efforts, they are entitled to an honorary membership and thus are not required to pay dues or assessments.

4. Electric bills?

The club pays.

5. Who is responsible in case of fire or injury?

Hopefully, the insurance company who was unlucky enough to think it was a shrewd move to sell insurance to the repeater group in the first place.

6. Can anyone with proper equipment use the repeater?

In general, yes – but with a few qualifications. In most cases, repeater groups will welcome all "transient" operators (operators who do not live in the area but who pass through occasionally and wish to use the machine). But if you live within the coverage area of a repeater and plan to use it to any substantial degree, your best bet is to join the repeater club. Only one or two cases have arisen where new members are discouraged; and these have blackened the eye of FM to such an extent that most groups lean over backward now to be courteous and friendly to newcomers.

7. Does one need permission?

Only when regular usage is contemplated.

8. What motivation is behind the establishment of a repeater?

The desire to have reliable communications over a given area, and the appeal of using walkie-talkies to do

polarized electrolytic capacitors in his manproofing scheme. If electrolytics are used here, they should be of the *nonpolarized* type, for two important reasons.

First, the dc polarity on many telephone lines frequently reverses. This polarity reversal is used in many instances for signalling purposes (called, curiously enough, reverse-battery signalling). It happens very frequently when toll calls, 211 (long distance) or O (Operator) are dialed. Since a great many phone patches are handled through an operator, a good possibility exists that the patch may indeed be run with a line polarity opposite to that of the coupling capacitors. This type of reverse-battery signalling is not universal, but its use is widespread enough to warrant a test for it before one uses polarized electrolytics (the line polarity will reverse after the last digit of a toll call or operator call is dialed).

The second reason for not using polarized electrolytics is that the ringing voltage is ac (20 Hz) and, should the patch be inadvertently left on and the phone rings, the ringing voltage could destroy the capacitors, causing the very thing you are trying to prevent. Further, the ringing voltage is approximately 110V rms, giving a peak-to-peak voltage of almost 300V. The voltage rating of the two capacitors must be at least 150V in order to safely withstand the peak voltages present during the ring cycle.

Ray Pichulo W1IRH
172 Dent St.
West Roxbury MA 02132

Nonpolarized electrolytics can be formed by series-connecting two polarized eletrolytics back to back. Connect the positive leads together.

. . .Ken

Better Understanding

The enclosed chart came across my desk the other day and it was immediately apparent that this is exactly what your readers need to bring them *on Skis*, in your issue of March 1971. In fact, we could make good use of some extra copies and would appreciate receiving some for our publicity purposes.

Once again, many thanks to the author, Gordon Pugh, and 73's staff for the excellent article.

John M. Christie
Vice President
Mt. Snow Development Corp.
Mt. Snow VT 05356

Circuit-Stik

You guys are really eating the green one. Why did you bother to turn everyone one with a description of Circuit-Stik without telling us how to get hold of the guys who purvey it? Let's get out of the "sled" position and straighten out this mess. Where can I get samples of the stuff? Who do I write to to get more information?

Richard Shyer
Mansion of the Slaves
2455 Barjud
Pomona CA 91766

I saw the article by Ken Sessions Jr. K6MVH about the PC Construction with the Circuit-Stik in a kit. Needless to say I was instantly interested. What is the address of this Circuit-Stik company, so I can send off for some more information?

Jim Vinnell W6DEU
851 California St.
San Francisco CA 94108

Your article on Page 61 March issue about Circuit-Stik was very interesting and we would like to try some. However, I've searched diligently and can't find out where to get it.

Please give me the supplier's name and QTH so I can get some.

Wm. H. Coleman K4DMD
Cornell-Dubilier Electronics
2652 Dalrymple St.
Sanford NC 27330

We recieved several hundred letters like this, all of which have been answered individually by the author, who was responsible for the oversight.

Expansion

I wish to express my wholehearted approval of the recent FCC proposal to expand the 'phone bands and to allocate more frequencies to the Extra class licensee.

I would also like to express my desire to see a reduction in the power limit for amateur transmitters. This would have to be in the form of a rule requiring a limitation on the total amplifier plate dissipation. The rules concerning dc power input are totally disregarded by many amateurs who run up to 10 kilowatts or more input to multiple 4-1000-As.

There is no adequate means of policing the present rule, especially when SSB is used. If an amateur's transmitter were limited to a total plate dissipation capability of 500–1000 watts with a mandatory license suspension for anyone with a larger transmitter in their possession, whether in use or not, it would be a great deal easier to enforce the rules.

Melvon G. Hart WØIBZ
936 Dontaos Dr.
St. Louis MO 63131

A Nice Letter

Yours is a fantastic magazine,– only wish I'd heard about it earlier. You have your competitor magazines beat 60 times over. Here are a few reasons why–

1. The General Class Study Course This is really just what I was looking for. As a Novice, which implies little more than an idiot in the ways of radio theory, I needed a step-by-step study course in some questions. Dry textbooks just don't compare. My dad, who is trying to learn the theory, and I both use the course and understand perfectly. When I am at the proper level, I will probably buy the Advanced Class Study Guide in your radio bookshop, and increase my theory with that, also.

2. Your Editorials.

I commend you for saying what needs to be said. The ARRL is an organization that is sorely needed by all hams in the U.S. but, as I am now aware, it is not the typical knight in shining armor. Keep up the good work. Inform us of the faults in the world of hamdom, and maybe 73 will soon be standard reading in ARRL headquarters.

3. Easy, workable, practical projects.

I may never need a $300 Morse-a-verter, nor a $500 homemade transceiver for 160 through 6, but these articles are great to look at and wish for. However, as soon as I finish the automatic keyer in the November 70 issue, I'll probably start the IC marker generator in the October issue. Your projects are all practical and needed items around the shack, and I intend to build a lot of them.

4. Your ads.

Believe it or not, my dad and I find your ads for 73 products simply supreme. What I am referring to, of course, is your subscription ads, your Gunsmoke ads, and of course: "Tell our advertisers you saw it in 73, even if you didn't." It's nice to know that hams have a sense of humor, also.

Unfortunately, I must cite the dark lining of your silver cloud. I agree with R. G. Kueha (letters, December). Your titles ARE quite large, and at least 1 or 2 other articles could be placed in each magazine if the space you now use as titles were halved. This is one change I would approve.

Anyhow, 73 is a fantastic magazine, and it is one worth getting. Thank you, and 73.

David Bekin WN6PYG
19856 Schoolcraft St.
Canoga Park CA 91306

Propagation

At one time the Propagation Chart by Mr. J. H. Nelson contained information on VHF openings. For the past many months this has been missing. How come?

Being a VHF operator I found this very helpful in looking for good band openings. Please if possible include FM Repeater Handbook & find it a very useful & informative publication.

Jack A. Rash

Reader service has been a fiasco, but things will improve with a new child-operated system we've initiated.
. . .Ken

The League

Oh boy! Did you persuade Wells Chapin, W8GI, or did he volunteer? His comments on ARRL, in your January 1971 issue are manna from some sort of heaven.

I too, am a member of ARRL with many years of support to my credit. Matter of fact, I am happy to reflect upon my status as a life member. But however you cut it, I am not happy with the image that ARRL is creating. Amateur radio is to some a hobby, and to some it is a vocation, so it cannot be administered to as a craft union. And it seems to me that, more and more, the approach of Newington lies in that area.

A thoughtful reading of Chapin's article will not only clarify cause and effect, but it will suggest ways and means whereby dead weight can be transformed into something approaching energy and purpose.

Alden W. Smith
Penury Priory
Temple NH 03084

The ARRL reminds me of a foghorn; at least with you guys I can tell that there's some*body* out there, and you're *different*!

You'd better keep Fred Mocking or I'm a goner – I made it through General on sheer momentum.

Pete Lamasney WB6AZF
654 Cunard Dr.
Napa CA 94558

There seem to be so many things that can be done by the League but with only one board meeting a year, the operation is basically run by the staff.

After two campaigns now for vice-director I have come to the conclusion in my own thinking that those who are vocal or want to see something done are no longer members and those who are left are just too apathetic and don't really care.

Caveat Emptor?

Price – $2 per 25 words for non-commercial ads; $10 per 25 words for business ventures. No display ads or agencydiscount. Include your check with order.

Deadline for ads is the 1st of the month two months prior to publication. For example: January 1st is the deadline for the March issue which will be mailed on the 10th of February.

Type copy. Phrase and punctuate exactly as you wish it to appear. No all-capital ads.

We will be the judge of suitability of ads. Our responsibility for errors extends only to printing a correct ad in a later issue.

For $1 extra we can maintain a reply box for you.

We cannot check into each advertiser, so Caveat Emptor. . .

this information in future issues.

Bill Peterson K9OWQ
P.O. Box 482
Midlothian IL 60445

The info is always there. Look on the last page of 73.

. . .Ken

Repeater Rules

I would like to know the latest on the FCC rules concerning repeaters. I have been out of touch for the last couple of months since my copies of 73 are going home while I am here for TDY. Thank you very much for everything.

Patrick Brown WA9FCG/5
CMR No. 4, Box 20016
Keesler AFB MS 39534

The FCC is just now beginning to consider the drafting of new repeater rules.

. . .Ken

A Real Mover

By all means renew my subscription to 73 for 3 years, as I couldn't *bear* to miss any of the fine educational articles mixed with a dash of humor to make life a little more *bearable*.

I started with you in 1960 in "6" land, to "7" land, to Ø land, and finally to 9 land. Hope you will not, ever, change your attitude toward bureaucratic boondoggling.

Larry Brooke W9LSS

Please do not speak ill of ARRL like that.

I Give Up

Well, you finally did it. After three months of sending in your Reader Service coupon, and not getting even one reply, I decided it was because I was sending in too many requests, or because I hadn't subscribed to your magazine, yet. So, enclosed you will find a money order for $6 for a one-year subscription, as well as the Reader Service coupon from the February issue. (The March issue hasn't hit my local newsstand yet, but I hope to get it soon.) All joking aside, I enjoy 73 very much and should have subscribed to it a long time ago.

I have recently purchased Ken's After hitting my head against the brick wall so many times I'm about to join the apathetic group and breeze along in other endeavors.

Gary A. Stilwell
7164 Rock Ridge Terr.
Canoga Park CA 91304

I do not wish to renew. I am tired of your lambasting the ARRL, "Leaky Lines" Dave Mann March 71. All Dave is interested in is a new country and not promoting goodwill among nations.

Vance E. Gildersleeve W5GST

Flix

Any groups like to see a film of the Westchester Amateur Radio Association's Field Day activities? We have about a 10-minute black and white documentary film on Super 8. Although the sound is presently on a separate tape, it can be put directly on the film.

I appreciate your study courses, and am waiting for the General series to be complete so that I may stand a chance in getting rid of my Novice call.

Elinor H. Stecker WN2MYK
(Mrs. Arthur Stecker)
16 Kilmer Rd.
Larchmont NY 10538

Poor Peoples' Radio

I thought you might let your readers know about Poor Peoples' Radio, Inc. We were granted a construction permit on November 19, 1970 from the FCC for an educational FM broadcast station to serve San Francisco. The proposed station has been granted callsign KFPR and we will operate on 89.5 FM with 10 watts output. We have permission from KGO-TV to place our antenna on their tower on Mt. Sutro, and this is the highest point in San Francisco, being about 830 ft. above sea level.

We are looking for help in the form of volunteers, money, parts, etc. If any of your readers would like to call me, the home landline is (415) 751-1974.

Meyer Gottesman W6GIV
863-25th Ave.
San Francisco CA 94121

Why is it that all the FM operation is being crowded into the 146–147 MHz segment of the 2m band. When is somebody there going to wake up and see the potential harm to amateur radio that is building up by allowing this situation to become further and further entrenched into our operating practices. As time goes on, the section 147–148 MHz is becoming more and more vulnerable to commercial take over. Its position in the spectrum makes it a natural objective for commercial radio users. Keeping amateur FM below 147 MHz is not helping matters any.

Joe Cusimano VE3OV
2480 Bayview Ave.
Willowdale, Ontario
Canada

You're running scared a little too soon. Remember, a few years ago there was no FM operation at all, and the AM people were spread over the entire 2 meter spectrum. Today, FM exists between 146 and 147 MHz (though many areas are active above that), and the AM'ers are settling above and below that 1 MHz spread. FM'ers are not made up of oldtime 2 meter AM men – they represent hams who have come from all areas of our spectra. Thus, the FM activity isn't causing a squeeze on 2 meters – rather it is causing an expansion of activity there.

. . .Ken

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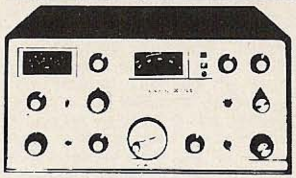

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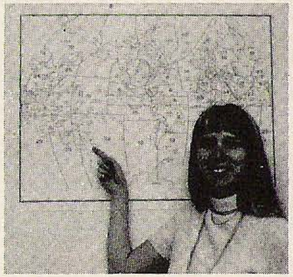

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The 75m mobile antenna I use raises a few eyebrows now and then, but it really works, and does so exceptionally well. It is the best performing 75m mobile antenna I have ever had the pleasure of owning. It is of the homebrew variety, using all commercially available components. There is nothing really new in its concept except that I have adapted the features of many different antennas to come up with one that maintains high Q and high performance over the entire phone band. It does look a little different and somewhat weird to those who do not know what it does and what it is for. The antenna consists of an adjustable top-section whip antenna, a three-spoke capacity hat, a long and large center-mounted loading coil, a rotary inductor (center mounted just below the main loading coil), a long tilt-over base section mast, and an inside-the-trunk base matching network (switchable).

The success or failure of mobile operation depends entirely upon the efficiency of the antenna installation. In mobile operation, one must compete with extraordinary noise levels, QSB, and high-power fixed stations. This immediately puts you at a distinct disadvantage. Considering all of these factors, the highest efficiency mobile antenna you can put on your automobile is obviously a must if you want good, solid communications. The physical configuration of my antenna was chosen with regard to the highest possible performance rather than how it looks.

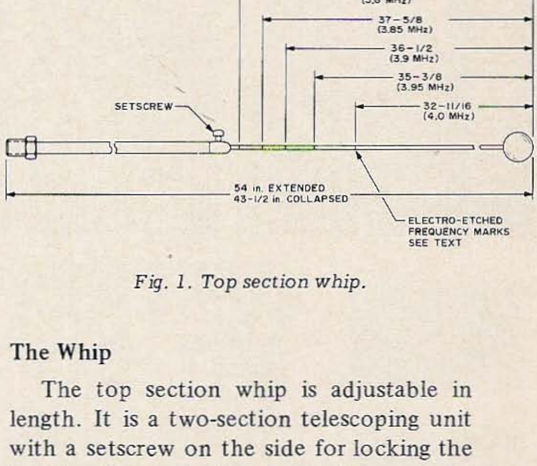


Fig. 1. Top section whip.

The Whip

The top section whip is adjustable in length. It is a two-section telescoping unit with a setscrew on the side for locking the length after adjustment has been made. The base of the whip is threaded and will mate with the top of the loading coil. The top of the whip has a large corona ball on it about ½ in. in diameter. The whip is made by Webster (No. MA-7). The extended length is 54 in. and the collapsed length is 43½ in. This gives me 12½ in. of adjustment. See Fig. 1.

Capacity Hat

The capacity hat (Fig. 2) is of the homebrew variety. It consists of three equally spaced (120 degrees apart) threaded brass rods 8¼ in. long. The use of this capacity hat above the loading coil effectively lengthens (electrically) the top section whip. The hat increases the effective capacity of the top section whip to ground. This also allows for the shorting out or removal of some turns on the main loading coil which is always desirable. The overall effect of the capacity hat is to bring the rf up into the upper portions of the antenna and away from the car body which has detrimental effects on performance such as absorption and detuning of the antenna.

The Loading Coil

The all important loading coil is the heart of the loaded low-frequency whip antenna. Its purpose is to cancel the negative reactance offered by the short antenna to the tuning device. The shorter the whip antenna (compared to a quarter-wave antenna), the greater the negative reactance offered to the tuning device. The loading coil adds an equal and opposite amount of positive reactance to the antenna circuit. This will neutralize the negative reactance of the short whip, leaving only the radiation resistance of the whip and the inherent losses of the loading coil as the terminating load for the tuning device.

Unfortunately, most loading coils are far from perfect. They exhibit resistance as well as reactance. The ratio of reactance to the rf resistance is given by the symbol Q. A coil having a reactance of 1200Ω and a resistance of 10Ω is said to have a Q of 120. If this coil is used with an antenna having a radiation resistance of 8Ω, the coupling efficiency is then 8(8+10) x 100, or 45%. Over half the output power of the transmitter is lost in the loading coil. If the radiation resistance of the antenna is only 4Ω (as it may well be with base loading), the coupling efficiency is then 4(4+10) x 100, or 28%. This means that 72% of the transmitter output power is lost in the loading coil. This power can only be dissipated in the form of heat generated in the loading coil itself. For this reason, I chose center loading. Improving the efficiency of the loaded whip antenna means increasing the radiation resistance of the antenna by using either a center- or top-loaded whip antenna. The center-loaded version is the most practical method to use from the standpoint of available commercial parts. I found out by experimentation that the longer, thinner coils, rather than the shorter, fatter ones, consistently gave me higher field-strength readings. This would indicate that the coil is actually radiating energy in conjunction with the whip antenna. With this type of coil, overall antenna efficiency should be on the order of 60 to 70%. The coil I chose was a Master-Mobile Ultra-Hi "Q" 75/80 meter loading coil (Fig. 3). It has well spaced coil turns (about 1/8 in.) to eliminate arcing at high power. The coil is 13½ in. long x 3 in. in diameter. The coil has 95 turns on it. It is housed in a clear plastic cover with yellow end caps.

The Rotary Inductor

The rotary inductor is a Master-Mobile Micro-Z unit. The basic rotary coil measures 1 x 3 in. long. The housing measures 3 x 4 in. It is designed for manual rotation and has a turns counter (numerals marked on one end cap). The tap to the coil is accomplished by a grooved wheel, mounted so as to slide on a bar. The grooved wheel rides on the coil. There is a coupling capacitor mounted between one terminal and one end of the rotary coil (Fig. 4). I removed this capacitor and discarded it and

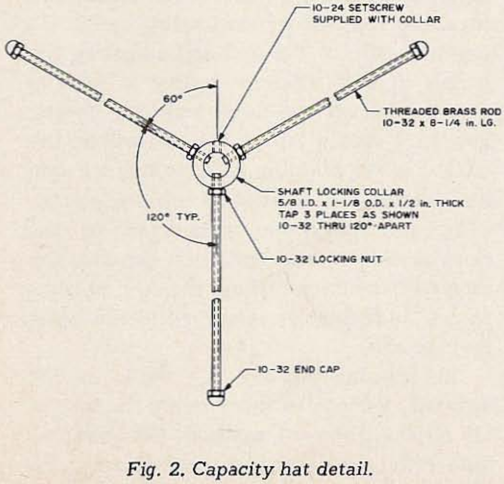


Fig. 2. Capacity hat detail.

made the input and output contacts continuous through the coil via the roller contactor. I fabricated a mounting plate for the rotary inductor which I mounted on the bottom side of the main loading coil. The rotary is mounted to one side of the main center line of the total antenna.

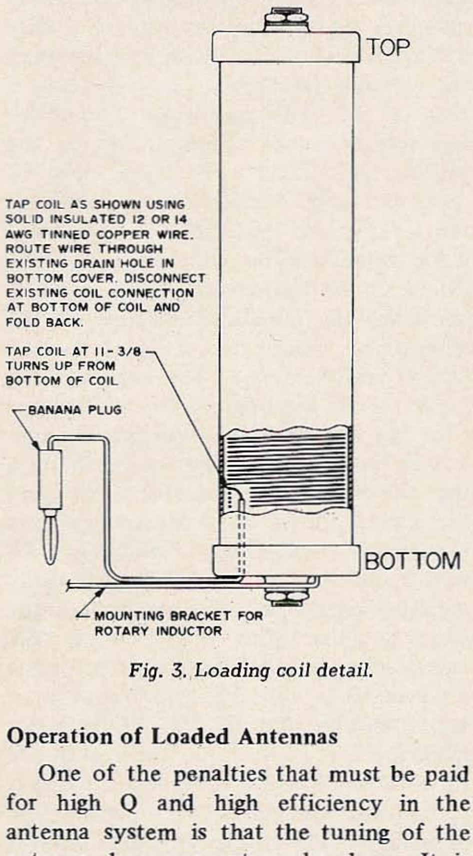


Fig. 3. Loading coil detail.

Operation of Loaded Antennas

One of the penalties that must be paid for high Q and high efficiency in the antenna system is that the tuning of the antenna becomes extremely sharp. It is necessary to adjust the loading accurately, and to adjust it for each significant change in operating frequency. To put this in practical terms, if the frequency is shifted 5 kHz without reloading, no appreciable loss will result; 10 kHz and the output and the plate current of the transmitter will start to drop; 15 or 20 kHz and the performance will seriously suffer. Obviously, some means must be provided for adjusting the antenna loading or some other portion of the circuit to tune out the antenna reactance at each frequency setting.

On 40 meters, the problem is somewhat less pronounced. First of all, the loading coil is smaller, and the whip is longer in proportion to the wavelength than on 75 meters. Changes in frequency of 30 kHz of the operating frequency may be made with no appreciable loss of antenna circuit efficiency. However, for changes of 50–100 kHz, again some means of varying the antenna loading must be incorporated in the antenna system.

Maintaining Antenna Resonance

On 10, 15 and 20 meters, the whip antenna (usually one electrical quarter-wavelength long) will usually tune the entire phone band or the entire CW band with little difficulty. On 40 meters, the loaded whip antenna will usually tune about half the phone band, and going beyond that requires some means of varying the inductance of the loading coil. On 75 meters, unless one is entirely satisfied with being restricted to one very narrow operating frequency, some means of varying the inductance of the loading coil is an absolute must. The resonant frequency may be varied by either of two basic means: by altering the length of the whip antenna above the loading coil, or by varying the inductance of the loading coil itself. I employ both methods. To vary the length of the top whip section by any other means than doing it manually is very difficult. To vary the inductance of the loading coil, one can do it manually or by remote control. Tuning this coil can be done by running an insulated metal strip from the top side of the loading coil down past the side of the coil and adjusting the length of this strip by rolling it up and down with an old-fashioned can opener key, or a sliding tap on the coil will do the trick. Or try running a brass slug up and down inside the coil with the slug electrically and physically connected to the bottom side of the coil. You can also use relays to switch in taps on the coil, or use a rotary inductor in series with the main loading coil.

In brewing up my 75 meter mobile antenna, I chose to incorporate the best of all of the different methods of obtaining high efficiency and high performance. To obtain high performance on 75 meters, one must first get the radiating portion of the antenna as far away from the metal body of the automobile as is practical so you won't suffer from body absorption and the detuning effect it has. I used a Hustler tilt-over mast. I chose to use the long mast (the one they normally recommend to use for bumper mounting), and mounted it up on the rear deck adjacent to the corner of the rear window. The ideal place, from the standpoint of efficiency, would have been right in the center of the roof, but I have to keep peace in the family. This tilt-over mast measures 55 in. long. With the extra heavy-duty stainless steel base spring, it brings the length of the base mast to exactly 5 ft long. The total antenna length approaches 10½ ft. This puts the top of the antenna about 13 ft in the air. This is a lot of antenna up there, but if you want to get out you must have a lot of antenna out in the air and have it properly matched and tuned. While driving, in order to keep the antenna in a vertical position, which is also necessary to maintain antenna resonance, I slip a large nonmetallic washer over the top

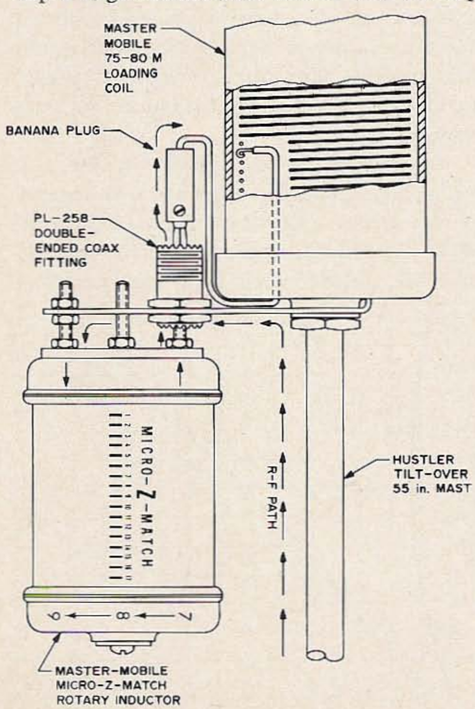


Fig. 4. Rotary coil detail.

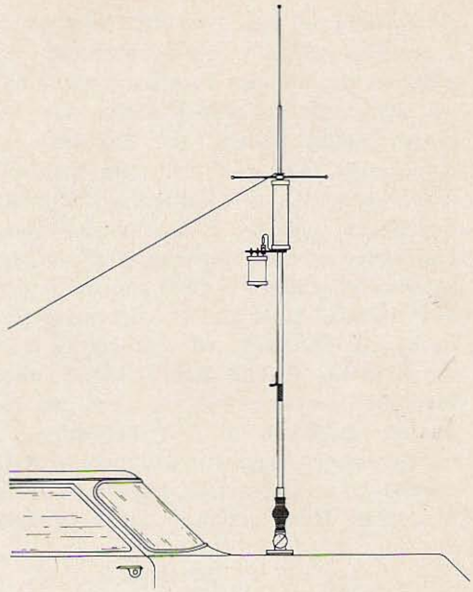


Fig. 5. Assembly and installation of 75m antenna.

section whip and let it come to rest on top of the loading coil. I drilled a small hole in one side of this washer. Through this hole I tie some waxed nylon lacing twine as shown in Fig. 5 and run it up forward to a gutter clip on the driver's side of the car. This is a very low-loss line and does not affect the performance of the antenna even when wet, because it is waxed.

Tuning the Antenna

Tuning this antenna was a relatively easy job. It would most likely have been a lot easier for me if I had used a grid-dip meter and an swr bridge, but I do not have either one, and I found out they were not really necessary. I tuned up this antenna using nothing but the cathode current meter on my transceiver and a field-strength meter. I am able to resonate the antenna in any 50 kHz portion of the 75 meter phone band with equal efficiency and still maintain the highest possible Q. It should be pointed out that most mobile antennas exhibit a feed-point impedance less than the characteristic impedance of the transmission line that feeds the antenna. You can match the feedline to the antenna by using a simple matching network. This network is composed of a rotary inductor which we will call L_M and a capacitor which we use to shunt the feed point of the antenna to ground with, and we shall call this capacitor C_M. The required values of C_M and L_M may be determined from the following formula. (See Fig. 6.) R_A is the antenna feed-point impedance and R_O is the characteristic impedance of the transmission line. If the antenna impedance is 20Ω and the line is 50Ω coaxial cable and the operating frequency is 4000 kHz, the inductance is as shown in Fig. 7. The chart at Fig. 8 shows capacitive reactance of C_M, and the inductive reactance of L_M necessary to match various antenna impedances to 50Ω coaxial cable. In practice, L_M need not be a separate fixed inductor nor a separate

$$C_M = \frac{2\pi f\,\text{KHz}\ R_O \sqrt{\dfrac{R_A}{R_O - R_A}}}{10^3}\ \text{pF and}$$

$$L_M = \frac{\sqrt{R_A(R_O - R_A)} \times 10^3}{2\pi f\,\text{KHz}}\ \mu\text{H}$$

Fig. 6. Equations for obtaining C_m and L_m.

rotary inductor, but I chose to have L_M a separate rotary inductor to give me more latitude and flexibility in tuning, as I wanted precise matching and maximum performance over the entire 75 meter phone band. L_M can be duplicated by adding an equivalent amount of inductance to the loading coil. If you choose to have L_M fixed and a part of the main loading coil, C_M at least should be variable until the appropriate value of capacitance is found. When this value is found, fixed, high-voltage capacitors of the same value can and should be substituted. A rotary (variable) capacitor can be used if you can secure the shaft by locking it in place so it will not change capacitance due to vibration.

I first started tuning up the antenna at the low end of the phone band 3.8 MHz. I did this by extending the top section whip up and out all the way and setting the rotary inductor so the maximum number

$$C_M = \frac{(6.28)(4000)(50)\sqrt{\dfrac{20}{50-20}}}{10^3}$$

$$= \frac{(1256)(10^3)\sqrt{0.6666}}{10^3}$$

$$= (1256)(0.816) = 1024\ \text{pF}$$

$$L_M = \frac{\sqrt{20(50-20)} \times 10^3}{(6.28)(4000)}$$

$$= \frac{\sqrt{600}}{25.12} = \frac{24.5}{25.12} = 0.97\ \mu\text{H}$$

Fig. 7. Inductance equations

of turns were in use. I used my transceiver to supply rf. I injected just enough carrier to get some output, then began running the tap up on the main loading coil until I started to get some output indication on my field-strength meter. I ran this tap up one turn on the coil at a time, retuning my transceiver each time to maintain resonance. I located the point on the loading coil where maximum output occurred and then backed up a turn or two and soldered the tap in place. I then started lowering the top section whip until I again obtained maximum output as indicated on the meter.

Once locating this point on the top whip, I marked it by using a low-voltage dc power supply with its output set at around 20V, clipped the negative lead to the whip and the positive lead to a lead pencil. I

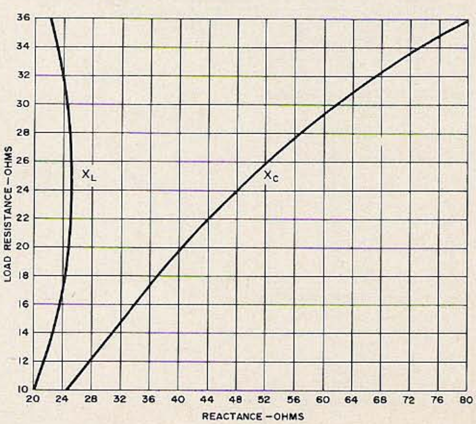
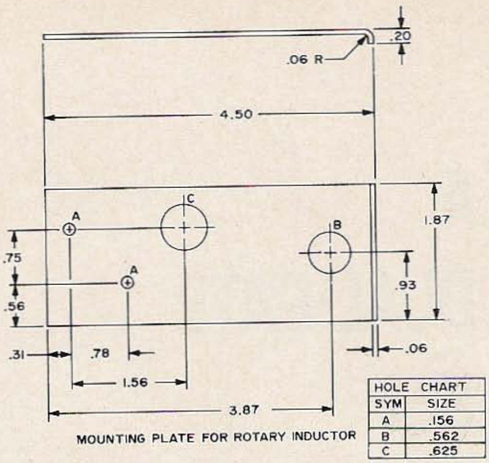


Fig. 8. Resistance-reactance chart.

touched the tip of the pencil to the whip where it resonated at 3.8 MHz and arced a ring around the whip. This mark is permanent and very easy to see. I then turned the rotary inductor all the way in and retuned the transceiver for maximum output. I found out that maximum output occurred at 3.85 MHz, 50 kHz up the band. I then ran the rotary inductor back to its original spot and retuned the antenna to 3.85 MHz by lowering the top section whip. When I again found resonance, I marked this spot in the same manner. I now had two marks on the top section whip, one at 3.8 MHz and one at 3.85 MHz. I tuned the rest of the antenna in the same manner. I now have electro-etched marks on the top section whip corresponding to 3.8, 3.85, 3.9, 3.95 and 4.0 MHz – the entire phone band. I can tune the antenna to exact resonance at any point in the phone band by raising up the top section whip to the lowest frequency mark below where I want to operate and tuning for maximum output on the desired frequency by rotating in the rotary inductor (reducing turns). In reference to the matching capacitor C_M, I shunt the base of my antenna with 1000 pF. I do this by using a ceramic rotary switch mounted on an angle bracket which in turn is mounted on one of the antenna body mounting bolts. This switch is a single-pole, multiple position switch. On this angle bracket I mounted the ceramic rotary switch, my matching capacitors and a coaxial fitting (Fig. 9). I can select any of 10 different capacitors, all of different values. The antenna I use on 40 meters is of the same principle; adjustable top section; three-spoke capacity hat, and a large high-Q coil, but no rotary inductor. C_M for that band turned out to be 500 pF. Figure 10, by the way, is a template for the 75m rotary inductor mounting plate.



HOLE CHART	
SYM	SIZE
A	.156
B	.562
C	.625

Fig. 10. Dimensions of mounting plate for rotary inductor.

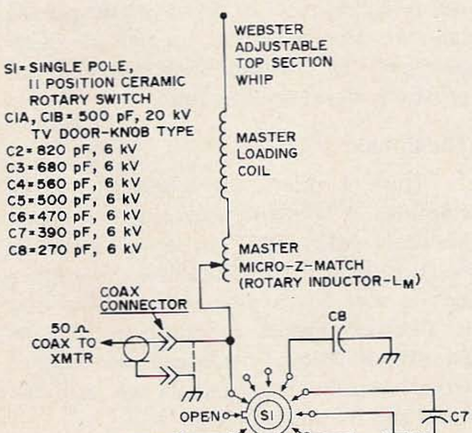


Fig. 9. Schematic of antenna circuit.

Results

The results I have obtained with this antenna have been beyond my wildest expectations. I can work anything I can hear. Ground-wave communication is excellent with little or no fade. To date I have worked many Atlantic Coast states with 5–9+ reports, many provinces in Canada, Alaska, Midway Island, Hawaii, Mexico, South America, and my latest ZL1BAZ in New Zealand with a 5–8 report. This antenna is terrific. I have only been able to work Hawaii from the QTH using the same power and a full half-wave inverted-V antenna; I've never been able to work any of the others. Contacts on 40 meters have been equally as good using the same system. In addition to the contacts mentioned, I've been able to work several KC4 stations in Antarctica. All contacts made were while I was mobile in motion.

W6MOG■

A DUAL-GATE FET PREAMP FOR 2 METERS

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Clifford Klinert WB6BIH
520 Division Street
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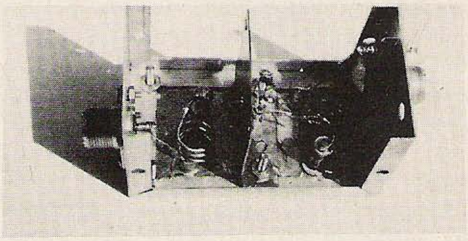

An rf preamplifier is a handy thing to have when there is a desire to improve the sensitivity of older receivers or to complete the construction of modern ones. The availability of dual-gate FETs makes it possible for the average experimenter to build a good front end for his receiver. This article describes such an FET amplifier that can provide about 20 dB of voltage gain to improve the sensitivity of fair or poor receivers. This preamplifier can also improve the signal-to-noise ratio.

The Circuit

Figure 1 shows the schematic of the amplifier. A common source unneutralized Motorola MFE 3007 is used. The input signal is applied to one gate, and the other gate is used for biasing. An rf choke and feedthrough bypass capacitor are used to improve isolation from the power supply. Experimentally tapped coils are used for input and output coupling.

Construction

The amplifier was built in a small aluminum box. The top was cut out and replaced with a copper plate, and a copper partition was soldered in the center as a

for the experimenter!

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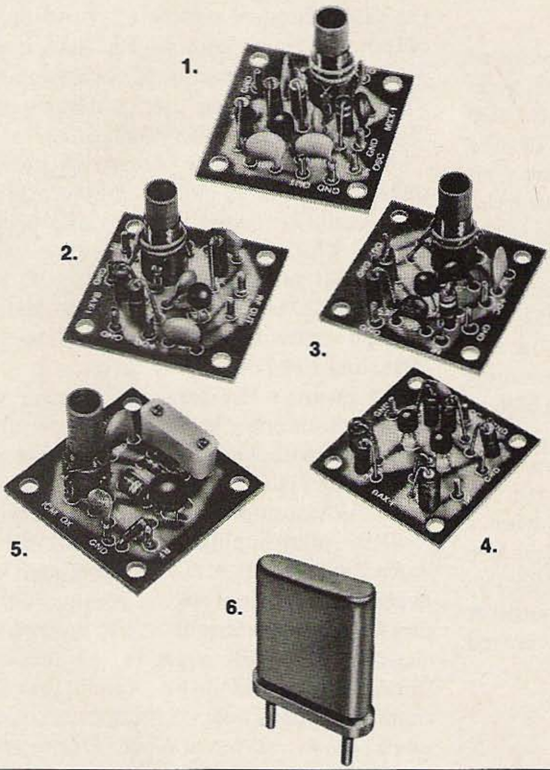

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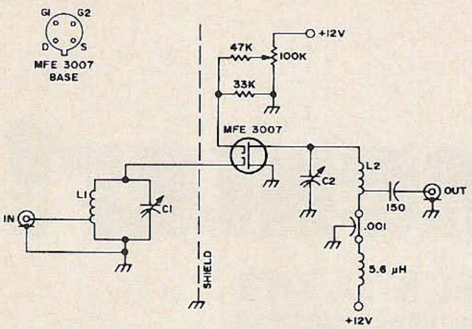

Fig. 1. 146 MHz rf amplifier.

shield. Both L1 and L2 were 3½ turns of 18-gage wire stretched to about ¾ in. long. The coils are ½ in. diameter. MC 603 trimmer capacitors were used for C1 and C2. They are 1–28 pF, but a variety of small variable types could have been used. The transistor was mounted on a clip in the center shield. L1 and L2 are mounted perpendicular to each other to minimize electromagnetic coupling. A 100 kΩ variable was mounted in the hole on the output side of the box, after the pictures were taken. Venerable UHF connectors were used for both input and output terminals. Since the MFE 3007 was susceptible to gate breakdown, all leads of the transistor were shorted together with a short piece of wire. The shorting wire can be just barely seen in the photograph. No problems were encountered with transistor damage, and when the wire was removed the amplifier functioned normally.

Adjustments and Operation

The first step in tuning was to set the tuned circuits approximately on frequency with a grid dip meter, then see that they tune above and below the desired frequency. Since an AM receiver was used, the avc was turned off, the audio gain was set at maximum, and the rf gain control on the receiver was used to control the output level. A modulated signal generator was used to obtain an ac voltage at the speaker terminals. A Ballantine VTVM with its good dB scale was used to measure the change in output signal. This setup makes it possible to estimate the gain of the preamplifier (assuming that the receiver was linear). With the gate bias set at zero, and a weak signal applied, all receiver rf circuits were tuned for maximum output.

The signal generator was placed about 100 ft away with a whip antenna attached. This precaution insured against stray coupling through the power lines and provided a simulation of actual operation since the station's usual 2 meter antenna was used.

After the tuned circuits were set up with zero bias, the 100 kΩ pot was turned slightly to increase the bias. This caused generally a decrease in output, but retuning the tuned circuits, mostly C2, brought the output up to a point higher than it was previously. This process of increasing bias slightly and retuning was continued until the amplifier broke into oscillation.

The bias was then reduced to provide stability and all rf circuits in the receiver were tuned to assure stability and proper tuning. This bias point produced 0.6V at the second gate as measured with a VTVM. The receiver was peaked up at 146 MHz as a compromise between AM (145 to 146 MHz) and FM (146 to 147 MHz).

To measure the gain, the receiver was set for maximum output just before saturating the audio, and the output voltage was noted. Removing the preamplifier and putting the antenna back on the receiver resulted in dropping the output voltage more than 20 dB. A 50Ω dummy load was applied to the input of the preamplifier to check its noise output. This showed an increase of 15 dB noise in the receiver. During these tests it was found that the amplifier took a few seconds to warm up when power was reapplied. During this warmup period the gain increases slowly and stabilizes.

This preamplifier provided a good increase in signal gain that, in some cases, has meant the difference between Q5 copy on a weak signal, and just barely being able to hear it. The receiver used with it was adequate enough in hearing external noise and it seemed that an increase in gain would only increase noise; however, several new signals popped up from about a hundred miles away that were not noticed without the preamplifier.

. . .WB6BIH■

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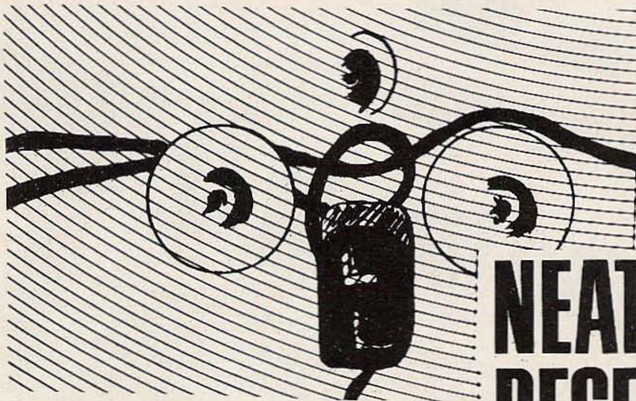


A NEAT & NOVEL RECEIVER ACCESSORY

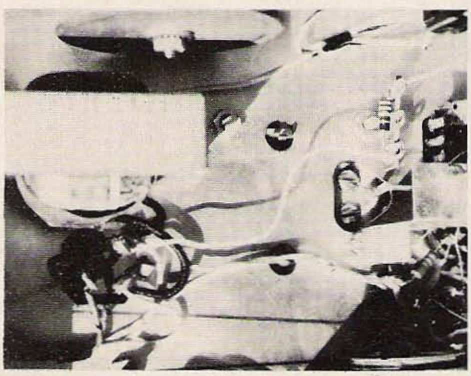
Paul Schuett WA6CPP
14472 Davis Road
Lodi CA 95240

In the mid-fifties, I purchased a Hammarlund HQ-100 receiver. This is not the best receiver ever made, but it is not the worst either. The unit has served me well for the past few years, requiring only an occasional tube change to keep it working.

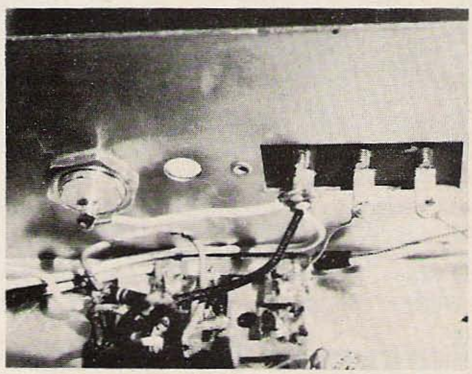
One accessory that is most useful is the crystal calibrator. This is inexpensive, and is easily installed even by the inexperienced in electronics. Since the dial calibration on this, as well as most other receivers, leaves something to be desired as to accuracy, the crystal calibrator finds it use in giving a marker at predetermined locations.

Let us assume we want to listen to a shortwave station at 15.175 MHz. The dial will get us to the right general area, but then we have to tune the bandspread all around, listening to about everything else on the band until we get to the right place – and even then we aren't sure until we hear an ID or a familiar announcer's voice.

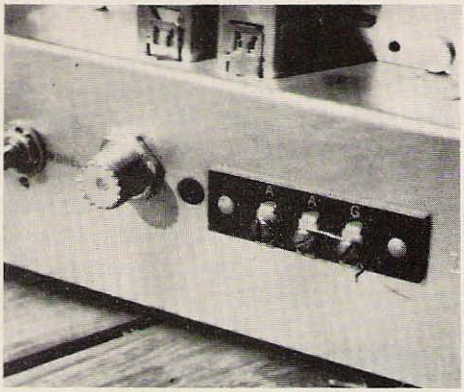
The crystal calibrator speeds up the process. When the switch is on, a signal is produced every 100 kHz on the band as a "marker." Looking for 15.175, we first find a reference spot such as WWV, count



The B+ wire from filter capacitor to dropping resistor. Note terminal strip mounted in a convenient place.



Inside of chassis showing connection of coax receptacle. Third wire on antenna terminal comes from calibrator.



Rear of chassis showing coax connector installed.

the 100 kHz pips on the way up until we are at 15.170. Halfway between .170's pip and .180's pip is our station. Simple.

This is so useful when using the bandspread since the calibration of the main dial is then almost useless.

For my HQ-100, I purchased the calibrator direct from the Hammarlund factory. The various makes of calibrators are all basically the same, so just about anything, including the battery-powered model, would work in the circuit. The suggestions I have for mounting the calibrator would work almost the same way in any popular receiver.

This is an extremely easy thing to do, so that even the newcomer could perform the steps with a screwdriver and a soldering iron.

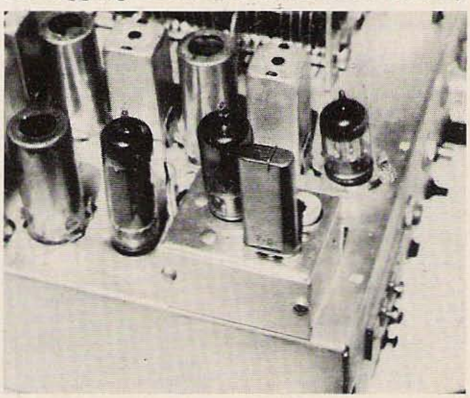
The Hammarlund calibrator comes with an on-off switch so that the unit will not be calibrating all the time (if you listen to a station on an even hundred, you will also get the calibration signal and this might be undesirable). The switch is in the B+ line to remove plate voltage from the tube when the calibration signal is not wanted. The switch can be mounted in any convenient place. I chose to mount mine on the front panel – but before doing any drilling, look around back to make sure you won't interfere with existing wiring or anything. The receiver's dials occupy a considerable portion behind the front panel; however, I located an area just large enough between them to mount the switch.

After the calibrator is mounted, it will have to be calibrated itself. Have the set warm up for at least a half hour so that all circuits reach operating temperature and there will be no drift. Tune to WWV, and wait until the tone stops and you hear only ticks. Adjust the capacitor on the calibrator to "zero beat." Wait another hour or so and check it again. It is best to use an insulated screwdriver for this process.

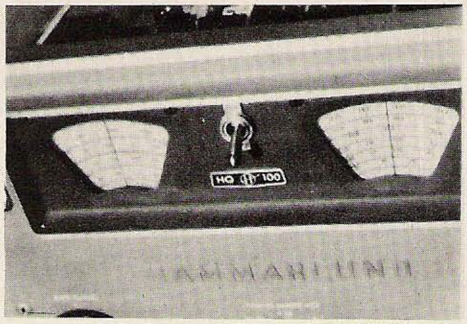
One other modification on my receiver is the installation of a coax antenna connector. Since I use coaxial cable for antenna leads, an inexpensive connector mounted in a spare spot on the back of the receiver is a great help. Drill a pilot hole where you want the connector to be, get it to the right size with a chassis punch, and you'll be in business. I used the type that requires only the single hole; the type that also requires the four holes for mounting can be used just as well – but this saved drilling four holes (and I never get them in straight anyway). Route a wire from the center connector to the antenna 1 terminal. A doublet antenna may still be connected to the terminal strip at any time; but for coax use, plug in the coax to the plug and short A2 to G on the antenna terminal strip.

I found a convenient spot on the chassis to mount the calibrator. The mounting position is not critical and can be almost anywhere. I tried to keep it away from the power transformer to minimize hum pickup.

Already drilled in the chassis was a hole which matched a hole in the little calibrator chassis – I lined these up and inserted a self-tapping screw. The calibrator is held by



Position of mounting crystal calibrator.



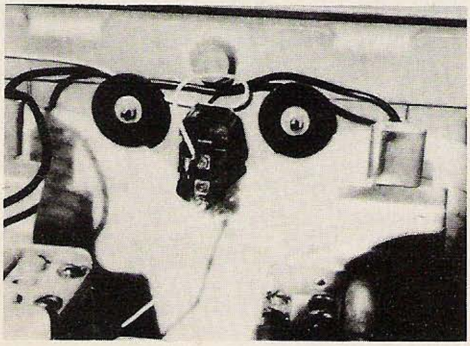
Front of receiver showing calibrator switch.

one screw, not two, even though a purist might shudder at this.

This calibrator had four long wires coming out of it. The instructions quite nicely told exactly what to do with each wire – filament, B+, antenna, ground – my only decision was where to route these leads.

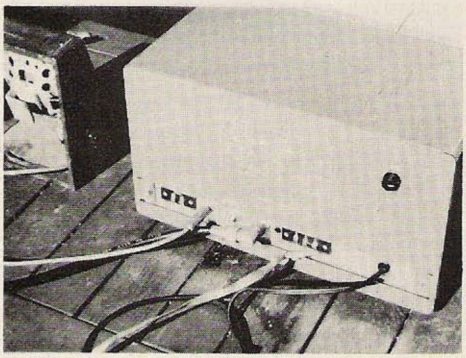
Fortunately, there are enough small holes already drilled in the receiver chassis that it was not necessary to drill another. The filament lead was routed to the nearest tube and soldered to the filament connection on the socket. The ground wire went right next to it and was soldered to a nearby ground lug. The antenna lead, of course, connects to the antenna terminal on the back of the receiver chassis. This produces no degradation of service, by the way.

There are many points in the receiver where B+ can be obtained. I took mine right from the filter capacitor. The voltage here was a shade higher than the instructions suggested, although performance of the calibrator was entirely satisfactory. However, the higher the B+, the stronger



Rear of calibrator on-off switch.

the calibration signal – and it is not necessarily desirable to have a strong signal, since the bandwidth will be greater. So I looked through the spare resistors and came up with one of 4.7 kΩ and tried it in series with the B+. It works great, so I am leaving it alone. Probably any popular size would work as well from 3.9 to 150 kΩ. I located an ideal place to mount a terminal strip under the chassis, put the resistor between the terminals, and broke the B+ lead, installing the resistor in this lead.



Rear of HQ100 ready for action. Notice 90° elbow on coax. Speaker plugs into phone jack – no change of impedance.

After using the radio almost fifteen years, I checked the alignment and found it to be off a bit. There was no problem aligning the unit, following the instructions in the manual, using a vtvm and rf generator. If you have these items, or could borrow them, there should be no problem in aligning this yourself and saving some cash. Maybe you could get friendly with a radio amateur or commercial broadcast engineer who would have you come over with your receiver and show you how it is done. When I first got going in the business, a fellow did this for me, and I learned how simple it is when you know what you're doing.

After installing the calibrator and coax connector, and aligning the receiver, the international bands come blasting in. Next project is to install a product detector, since receiving SSB signals using the bfo and fooling around with the rf gain on manual volume control is something less than satisfactory.

WA6CPP■

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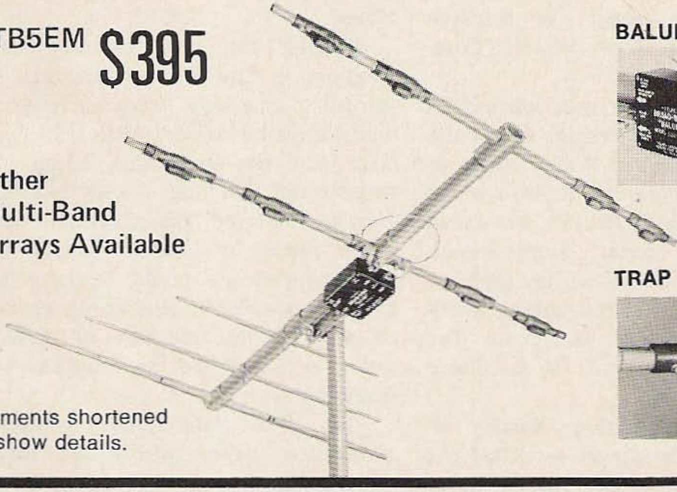

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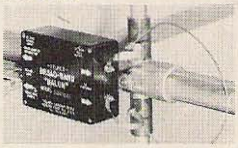

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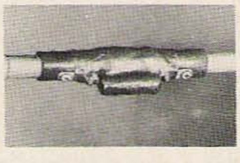

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THE HARTLEY OSCILLATOR STORY

A tribute to R.V.L. Hartley who, until his recent death, was one of the last of the real electronic pioneers.

Ralph V. L. Hartley, inventor of the Hartley oscillator, died on Friday, May 1, 1970, at Overlook Hospital in Summit, New Jersey. He was 81 years old.

Ralph Hartley graduated from the University of Utah in 1909 and studied for the next three years at Oxford University as a Rhodes scholar. After returning from England, he joined the research laboratory of the Western Electric Company.

Early in 1914, the transcontinental telephone line was near enough to success that the chief engineer of AT&T began to seek new fields to conquer. Radio seemed promising and so Ralph Hartley was asked to look into the matter. Soon experiments were going on and within the year Ralph Hartley invented the famous oscillator circuit that bears his name. The earliest known drawing of the oscillator circuit is shown in Fig. 1.

Also during this period, Hartley invented a neutralizing circuit to offset the internal coupling of triodes that tends to cause singing. He soon became the acknowledged expert on receiving sets and when tests were made from a transmitter connected to the Navy's antenna at Arlington, he was listening in San Francisco.

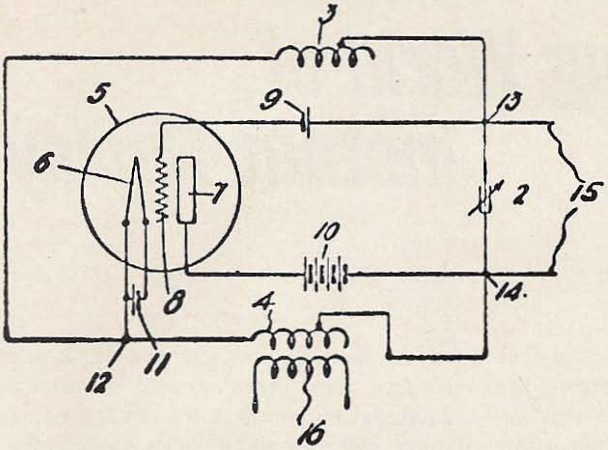
During World War I, while working on the problem of binaural location of a sound source, Mr. Hartley formulated the now-accepted theory: that direction is perceived by the phase-difference of sound waves due to the longer path to one ear than to the other.

Following the war, Mr. Hartley was placed in charge of research concerning repeaters and voice-and-carrier transmission systems. This work was first carried out at the Western Electric Company and later at Bell Telephone Laboratories.

During the next decade, his keen imagination and skillful guidance carried the art a long way. Many early models of voice-operated devices were made in those days; one was the vodas, which prevents sing-around in long 4-wire circuits. Mr. Hartley fostered the treatment of telegraph pulses by Fourier analysis so that ac measurements could be used in telegraph transmission studies. In an attempt to secure some measure of privacy for radio, he developed the simple frequency-inversion system.

In 1923, Mr. Hartley published a pioneering paper which set forth the relation of the carrier and sidebands in radio transmission and discussed the many advantages of single-sideband suppressed carrier transmission. The telephone companies soon adopted SSB but it was not until the amateur, in the years following World War II, popularized the mode, that other commercial organizations and the military saw its many advantages.

At about this same time, selective



Hartley's oscillator as it appears on his patent granted Oct. 26, 1920. It took more than 3 pages of very small type to describe the operation of the oscillator. The device, granted patent 1,356,763, was called an "oscillation generator."

filters were being developed and it was Mr. Hartley who first analyzed the mechanical filter and discussed its many advantages.

Broadly, however, Mr. Hartley's contribution was the intangible one of clarifying ideas and arranging them into a useful pattern. Nowhere is that talent better seen than in a paper entitled "Transmissions of Information," presented at an international conference at Lake Como, Italy, in 1927, which brought together a lot of ideas that had been implicit in the thinking of transmission men. Here he enunciated the law, later to be known by his name, "The total amount of information which may be transmitted over a system is proportional to the product of the frequency range which it transmits by the time during which it is available for the transmission."

After a period of failing health had halted Mr. Hartley's active work, he returned to Bell Laboratories in 1939 as a research consultant on transmission problems. He continuned in that capacity until his retirement in 1950.

During his active career, he received many awards and honors, including the Medal of Honor of the Institute of Radio Engineers, and fellowship awards in the Institute of Electrical and Electronics Engineers and the American Association for the Advancement of Science.

He was awarded 73 patents for his pioneering inventions.

Although never himself an active ham, he was well aware of the activities of amateur operators and was proud that many of his contributions had found acceptance in this group. In 1968, he was honored with a life membership in the New Providence (New Jersey) Amateur Radio Club, and only recently the Board of Directors of the Antique Wireless Association voted him an honorary membership.

After his death, the following resolution was unanimously passed at the New Providence Club:

> *The officers and members of the New Providence Amateur Radio Club, Inc. note with profound sorrow the death of Ralph V. L. Hartley, an honorary life member of this organization.*
>
> *The many contributions in the field of electrical communications made by Ralph Hartley will continue to influence the entire scientific world, including that of amateur radio, for years to come, as they have in the past. We are thankful that he used his time on earth for such inventive activities.*
>
> *His death is a great loss to us and to the entire amateur radio fraternity.*

K2SKV■

The Widening World of

The Widening World of Instant Replay

Like the sports fan watching an "instant replay" of a television touchdown, the $100,000,000 closed-circuit videotape recording industry is benefiting from a second look at itself.

Just over four years ago, compact inexpensive videotape recorders emerged to vitalize the closed-circuit television industry that serves education, business, industry, medicine, government, sports and many other fields. Their role in this diverse market is coming into clear focus after four years of rapid growth.

Born out of the needs of the broadcast television industry, refined and matured through demanding daily use in schools and colleges, business training centers and a host of other environments, the videotape recorder is on the verge of becoming a practical home entertainment device.

The versatile videotape recorder records moving pictures and sound on magnetic tape for immediate and repeated playback. Ampex Corporation, Redwood City, California, developed the first practical videotape recorder in 1956. It was large – more than 1,000 pounds – and expensive, and was designed exclusively for use by television networks and stations. Most television programs seen today are broadcast from successors of this type of videotape recorder.

The 1966 introduction of low cost, portable VTRs – weighing less than 100 lb and priced from approximately $1000 – unlocked the door to a vast number of potential users and stimulated the use of closed-circuit television in many fields.

More than 65,000 low-cost videotape recorders have been placed in service throughout the world in the last few years. Industry sales of small VTRs have grown from approximately $15 million in 1966 to $40 million in 1970, in addition to an estimated $60 million in related accessories. By 1975, Ampex estimates annual sales of compact videotape recorders, accessory equipment and software for serious closed-circuit use will be approximately $200 million, not including home or consumer use.

As this market has grown it has developed identifiable patterns of use and equipment requirements. Three broad subdivisions of the market have emerged:

Repetitive programming. This is the requirement of the professional closed-circuit television user who wishes to produce quality programs on video tape for wide distribution and frequent playback. As such it calls for two distinct kinds of equipment – high-quality versatile production recorders and simple, inexpensive playback units. Schools and universities, business, industry, and government agencies are typical users in this area. Ampex videotape recorders using 1-inch-wide tape with electronic editing, special effects, and guaranteed interchangeability from machine to machine are the leaders in the production portion of this market section.

Semirepetitive programming. In this category production sophistication, electronic editing, and studio techniques are less important; economy and portability are more important. Classrooms and small training centers are typical markets.

Instantaneous response. In this category, the value of the information recorded is in the immediacy and convenience of the presentation, with little or no concern for future use or distribution. Portability, economy, and simplicity are the major factors. Recorders using the 1/2 in. format dominate this market. Applications are extremely varied and embrace a wide range of fields.

Two portions of the closed-circuit VTR market are expected to experience the most rapid growth in the next few years. One is the *instantaneous response* category, the other the *distribution portion of the repetitive programming* segment. These fields both call for compact, economical, and easy-to-operate equipment.

The market for high-quality production equipment for the repetitive programming segment of the market will continue to grow as the emerging compact distribution recorders make the playing of recorded presentations more simple and economical. High-speed tape duplication systems now under development will similarly stimulate both the use of production recording equipment and distribution playback devices.

It is from product developments for the distribution and instantaneous response portions of the market that the long-awaited home videotape recorder/player will most likely emerge. The same basic requirements sought for these uses will be demanded in even greater degree by the consumer.

As a recording device, the home videotape recorder must be extremely compact and inexpensive. It must be at least as easy to operate as a cartridge-loading movie camera and provide color recording capability as well as monochrome. For playback, it must be as easy to load as a cartridge or cassette audio recorder.

Developments by Ampex and others in this direction indicate that a true home videotape market, which presently does not exist, may well emerge in major proportions over the next several years.

The contenders in this emerging field are arrayed in two basic camps – those that propose playback-only systems for viewing recorded entertainment through home television receivers and those that propose systems that not only play previously recorded material but can record at home, or anywhere, or tape programs off the air. Ampex is in the latter camp.

"We believe the forthcoming home market will best be served by equipment that not only plays back cartrid loaded recordings but permits completely portable or off-the-air recording as well. We are confident that this can be combined in a videotape system completely competitive in cost with any of the playback-only systems presently proposed," says William E. Roberts, Ampex president.

What is a Videotape Recorder?

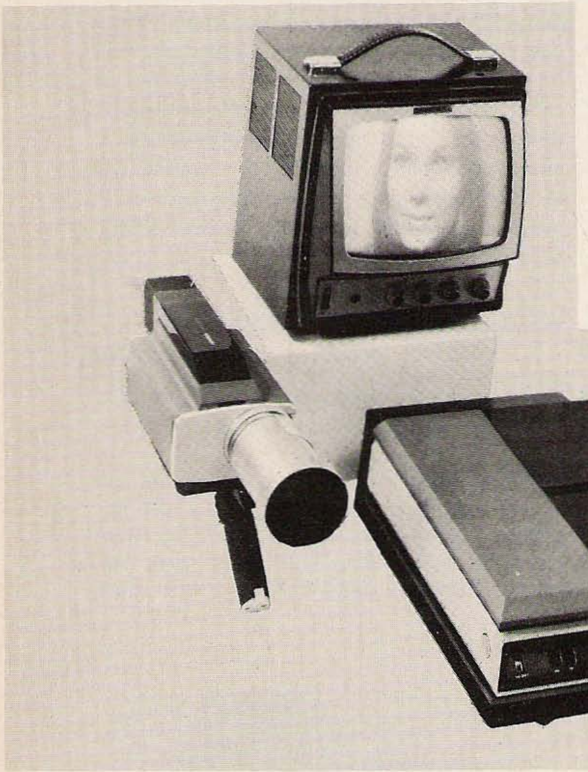
A videotape recorder records moving pictures (color or monochrome) and sounds on reels of magnetic tape much as a conventional audio tape recorder records sound.

Audio tape recorders record sound either from microphones, from a radio receiver, or by duplication from another recording. Similarly videotape recorders record television pictures from a television

The new Instavision recorder/player uses standard half-inch video tape enclosed in a small circular plastic cartridge. The cartridge-loading system is the smallest to date. The cartridge is compatible with all reel-type recorders using the Type 1 half-inch standard. The blank cartridge will hold up to 30 minutes of recording time at the Type 1 standard or 60 minutes in an extended-play mode. Instavision recorders and players operate from internal batteries or household current, in color or black and white.

camera, from a television receiver or by duplication from another recording. In addition, sound tracks on the video tape itself permit audio recording from microphone or television set on the same tape with the television pictures.

In both audio tape recording and videotape recording, the basic method is the same. Sound or visiual images are converted to electrical signals by a microphone or camera. The electrical current varies in direct relationship to the sound or picture and produces a comparable varying flux in an electromagnet (the recording head).



Instavision videotape recorder/player system includes a miniature videotape recorder, a handheld camera, and a cartridge using half-inch video tape. It is said to be the smallest cartridge-loading video recorder or player system. Pictures may be played back for viewing on a standard television set. Initially, the entire system (less monitor) will be priced under $1500. Tape cartridges will be priced under $13 for up to an hour of recording. The system may be operated by batteries or household current, in color or black-and-white.

A plastic tape coated with iron oxide is passed through this changing magnetic field. The iron oxide particles on the tape are thus magnetized in specific patterns which correspond to the original sound or picture. When the process is reversed, and the electric signal detected from the tape is amplified through a speaker or television tube, the original sound or picture is reproduced.

Just as with the audio recorder, videotapes may be played back immediately without processing by connecting the videotape recorder to a television set. Recorded tapes may be erased on the recorder, in part or entirely, and reused hundreds of times without loss of quality.

Of the various devices proposed for use in closed-circuit television applications in the home and elsewhere, only those using magnetic recording techniques are capable of *recording* and playing back pictures and sound. Those not using magnetic recording are *playback only* machines. These playback only devices are limited to playing programs previously recorded on complex specialized systems.

Audio tape recorders provide high fidelity stereo music at frequency responses up to 18,000 hertz. Much higher frequencies are required to record television pictures. Ampex studio videotape recorders for the broadcast industry record at more than 5 MHz.

Frequency response is directly related to the speed at which tape moves past recording and playback heads. In audio recorders, tape moves past the heads at 7½ in. per second, the accepted standard speed for high quality performance. In making the transition upward from audio recording frequencies to video recording frequencies, engineers have successfully used two basic

New Ampex Instavision system is the smallest cartridge-loading videotape recorder/player. It is designed for home recording and playback as well as serious close-circuit television use. The hand-held camera weighs 5 lb and the recorder/player, which can be carried with a shoulder strap, weighs less than 16 lb – including batteries for portable operation. A trigger built into the pistol-grip handle enables one person to operate both camera and recorder. The recorder may also be operated with household current for recording and playback in color or black- and-white.

techniques to increase the relative tape to head speed. A third method has been tried unsuccessfully.

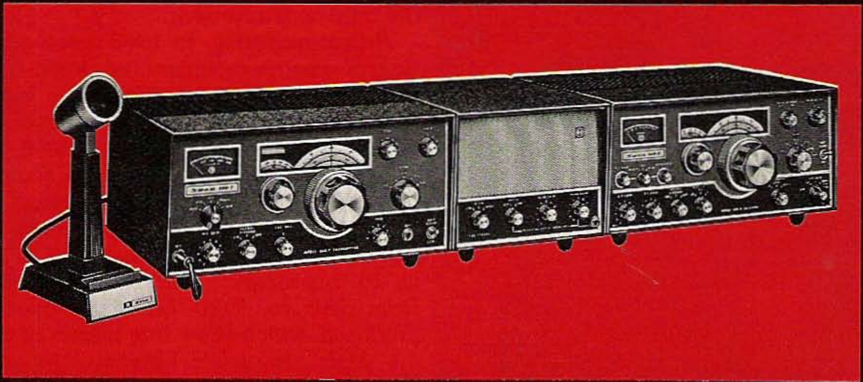
Transverse recording. In 1956, Ampex created the rotary recording head and a technique called transverse recording. Video tape is moved past recording heads at 15 or 7½ in. per second. However, four record/playback heads are mounted on a disk which is rotated rapidly across the tape at virtually a 90-degree angle to the path of the tape. In this manner, the "relative" tape speed is increased effectively to 500 in. per second. At this speed, frequencies of more than 5 MHz may be achieved. Such frequencies produce television pictures with the color and monochrome quality necessary for broadcasting. Virtually all videotape recorders used for broadcasting throughout the world employ the transverse approach.

Helical recording. In 1963 a new generation of smaller recorders for closed-circuit use was introduced, utilizing the helical-scan principle. In this case, one or two record/playback heads are mounted on a rotating scanner and record a series of diagonal tracks across the tape. Actual tape speeds vary from 3.75 to 9.6 in. per second. Tape widths vary from a ¼ in. to 2 in. In this manner, relative tape speeds of from 280 to 1000 in. per second are produced, which allow frequencies of up to 4.2 MHz. In some instances, broadcast quality and color recordings are possible at these frequencies. Nearly all videotape recorders used in closed-circuit television are helical scan recorders.

Longitudinal recording. Since the 1950s various attempts have been made to develop videotape recorders using the same longitudinal recording technique used in audio and instrumentation recording. None have produced satisfactory quality. In this method, tape is moved at very high speeds past stationary heads which record parallel to the tape path. Even at tape speeds of more than 100 in. per second, frequency response of only 1.5 MHz has been attainable. This provides unsatisfactory picture quality and, coupled with a high consumption of tape for a small amount of recording, has prohibited development of a successful longitudinal videotape recorder.

. . .Staff■

introducing



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Design Concepts For Low-Power Amplifiers

David Campbell
Richard Westlake
Fairchild Semiconductor
Mountain View CA 94041

The purpose of this article is to review the present capabilities of transistors for low-power amplifiers and to note some recent circuit developments which have given designers more efficient systems. Two developments will be discussed: A new circuit viewpoint that emphasizes the function of the circuit; and a new family of devices which was designed for low-power complementary amplifiers.

Gain Characteristics

In the past, small geometry silicon planar transistors have not had good high current h_{FE} characteristics. The PNP's have been especially poor because of their inherently higher saturation characteristic. This situation has now changed with the advent of the two silicon transistors illustrated in Fig. 1. These new products are competitive in both performance and cost with germanium medium-power complementary transistors. The curves in Fig. 1 compare the worst case h_{FE} I_C loci for the new (upper curves) and the old silicon (lower curves) devices. The improvement is obvious. The new NPN and PNP transistors adequately fulfill the transistor h_{FE} requirements.

Power Dissipation

In a small-geometry transistor for class B audio applications, the rated dc dissipation serves as a guideline for average junction temperature calculations based on the thermal resistance of the package and the heatsink used. The low-cost requirement usually dictates the package design and resulting dc power dissipation capability. An important property that is built into these new device package combinations for class B applications is the ability to dissipate power on a repetitive transient basis. This property may be defined by the "pulsed safe-operating area" of the transistor.

Fig. 2a shows the safe area for a metal conversion of these new transistors at a case temperature of 70°C, with the dc curve indicating the average thermal power limitation. The pulsed power curves demonstrate the transient capabilities of the device. It is clear that a significant difference exists, and that a much higher power may be dissipated on a transient basis. These pulse curves will vary as a function of the case temperature and package for any given transistor die type. Fig. 2b shows the same data for an epoxy version of the new silicon transistors.

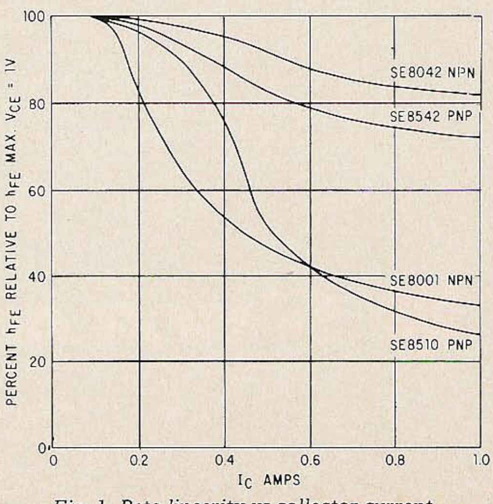

Fig. 1. Beta linearity vs collector current.

The 5 ms 50% duty cycle curve shown in Fig. 2b should be adequate for most audio applications involving repetitive low-frequency signals. The 1 ms 10% duty cycle curve is valuable in evaluating high-energy transient phenomena in switching applications.

Use of Safe-Operating Area Curves

Load lines for the output transistors in a complementary amplifier should be determined for various frequencies. This is necessary in order to make a realistic appraisal of the transient power to be dissipated by the output devices. This is best done empirically.

Fig. 3a shows a typical 1 khz sinusoidal load line for an amplifier operating from a 28 v supply into a 16 ohm resistive load. At 60 hz, as shown in 3b, the load line indicates that the transistor must dissipate considerably more power at V_{CE} of 15 v than in the 1 khz example. This is caused by the phase shift due to the output coupling capacitor. If the load line exceeds the safe area curve for a time longer than the specified period, the design should be considered unreliable, and appropriate action should be taken to reduce the power dissipated to a lower level.

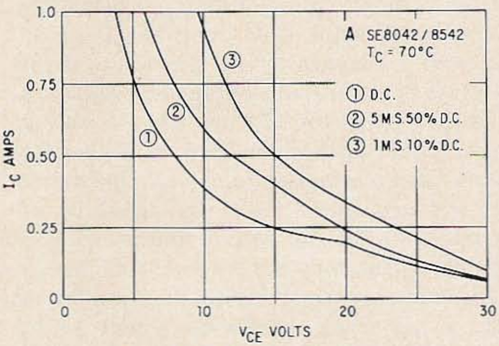

Fig. 2a. Safe operating area.

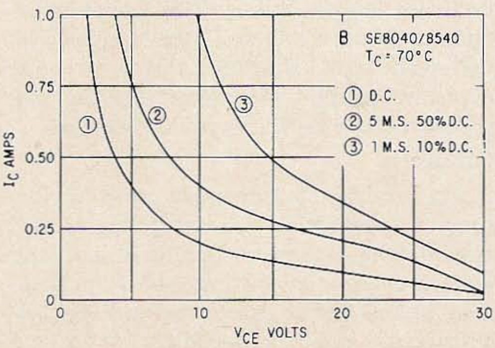

Fig. 2b. Safe operating area.

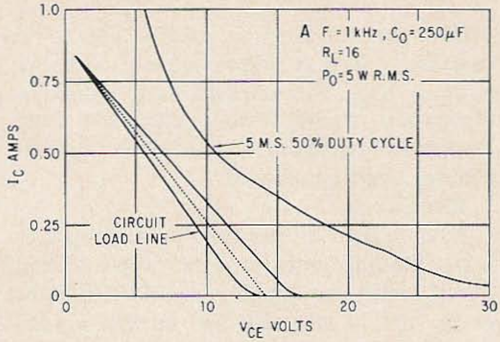

Fig. 3a. Load lines.

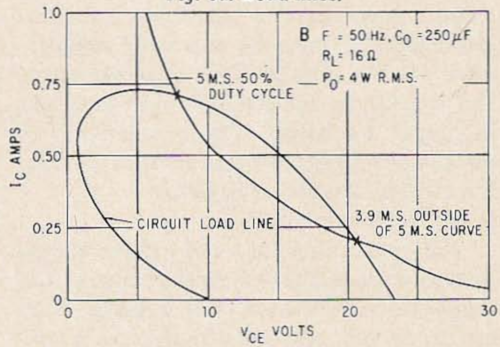

Fig. 3b. Load lines.

The General Amplifier

The low-power complementary amplifier (Fig. 4)) has been in use for three to four years. This amplifier was used initially (in a variety of forms) to replace the class A vacuum tube output stage. The basic circuit has been described in the literature on many occasions, usually superficially, and often without understanding the transistor characteristics and problems. Frequently circuits have been designed with fundamental failure modes. It is appropriate to list some of the fundamental design problems. These problems have little to do with how an amplifier sounds. Rather, they are problems relating to reliability of the amplifier.

1. Output Capacitor Charge and Discharge

There should be some way to keep the charging current for the output capacitor to a "safe" level for turn-on, turn-off, switching transients, etc. C_2 of Fig. 4 must be charged by R_1 before any current can flow in Q_1, Q_2, or Q_3. This time constant should be long enough to keep Q_3 within its dissipation ratings. On turn-off, C_4 discharges through C_3, R_5, R_6, and R_L instead of Q_4.

2. Power Dissipation

The output transistors should be operated within their dissipation rating. Since the amplifier's output transistors are operated without bias, the amplifier is a minimum dissipation circuit. This makes the total dissipation capability of the transistor available for signal conditions.

3. Bias Circuit

The method of bias used in this amplifier is not the only one, but some stable biasing circuit must be employed. Most failures occur simply because the circuit in the amplifier is not thermally stable. A bias circuit must have a very low terminal impedance, it must be thermally compensated for the shift in V_{BE} vs. temepratur e, and it must be adjustable for the variations in output transistors. The alternative is to operate the output transistors without bias, the method chosen in this design.

4. DC Operating Point

The operating point of the output should be well defined and temperature stable. The temperature coefficient of an amplifier is set by its dc gain and the temperature coefficient for the gain stages. One very useful way to insure negligible drift is to make the dc gain unity. If this cannot be done, as in the circuit shown, then an upper limit must be imposed on the gain. For this circuit a gain of 20 db will give a shift of 0.6 v of the dc output level for a temperature shift of 25 to 55°C. The tolerance of the initial dc voltage should be established without depending on the transistor parameters. The tolerance on the resistors setting the output voltage should be close enough so that the output dc does not vary significantly from unit to unit.

The above problems are not the only ones associated with the design defects, but they are the ones which have been the subject of

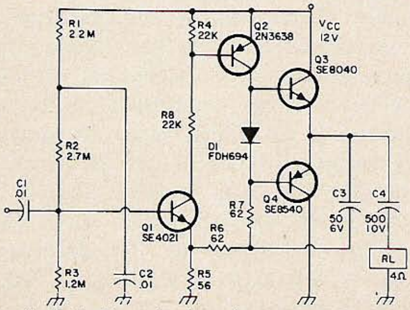

Fig. 4. Gain linearity is unimportant for distortion determination because of feedback.

recent questions.

Circuit Problems

The function of these amplifiers is to supply sufficient power gain to a system to drive the transducer. The amplifier should be reliable, reproducible, inexpensive, and should meet the required performance. Any circuit design which satisfies those goals is, by definition, a good circuit. Requirements differ, but virtually all the circuits operate in the current mode. The output transistors are operated from some form of current source, whether it is a resistor bootstrapped by the output capacitor or by a separate capacitor from the output into the collector load of the driver stage. In most circuits current gain and current gain linearity have significance due to the system power gain requirements and the amount of available feedback in the system. In the circuit of Fig. 4, gain linearity is not important in determining large signal distortion of the amplifier because the amount of feedback is sufficient to reduce gain non-linearity to a second order problem.

One point should be made about the output circuit. The output stage is driven from a voltage source for signals below the output transistor dead zone and the load current is supplied by Q2. The signal at the output is attenuated from the base signals of Q3-Q4 by the ratio of R7 to R_L. The output dead zone can be calculated by noting the load current required to change the current in R7 enough to reach the threshold of conduction for the output transistors. This would explain why the low-level distortion is not dependent on the load. The non-linearity at low levels in unbiased circuits can be improved by replacing the bootstrap with a transistor current source. This would maintain the forward gain at a high level even in the dead zone. However, this is a more expensive method of current sourcing and probably is not justifiable in most designs.

Conclusion

This article has discussed some of the problems associated with the design of low power complementary amplifiers and has presented material that should help eliminate present design defects and make future designs safer a nd more reliable.

. . . David Campbell & Richard Westlake

the price of 10 extra feet

The big day had arrived. My borrowed gin pole was still tied to the door handles of the Rambler in the driveway. The 10 ft section of tower lay on the floor of the garage. The job that lay ahead was pillow-plotted many times. The idea was to add the additional section to my 40 ft tower without the time-consuming disassembly of beam, rotor, and associated components. I was going to remove the top section complete with rotor and beam and lower it to the third section where it would be lashed up. The new section would then be raised and put in place.

My friend Jim came driving up shortly after the arrival of my nephew, Elliot, who had offered to help. Jim, K9TRJ, had heard my plan many times, but I took 10 minutes to outline the strategy to my 14-year-old nephew. The youngster, suffering the results of an extended adolescence, is six-foot-three of uncoordinated youth – willing, but sometimes inclined to release when he is asked to pull. Jim, on the other hand, is wise to the ways of hamdom, but is somewhat prone to rope-burn.

Eagerly, I scampered up the tower. Getting the bolts out of the top section was a cinch. Getting the gin pole up and securing it presented no difficulty either. On the third trip I carried up the tire jack from my Mustang. An advisor at the local radio store said this would be the ideal tool to get the sections apart. I secured the jack to one of the iron angles of the tower with a length of wire; just in case it got away. I wouldn't want to strain family relations by permanently brain-damaging my nephew with a falling jack. I began to jack and watched the sections part as the boys grunted below. The ground crew made an attempt to lower the section smoothly, but their hand-over-hand methods produced a convulsive jerking of the section. Finally, it reached the third level and I hurriedly tied it up with a tangled bundle of 14-gage electrical wire, a commodity on which I was long.

Getting the shiny new section in place was comic relief, but going up for the fourth time was beginning to tell on my 39-year-old legs. After tightening the new bolts in place and resetting the gin pole to the top section I returned to terra firma and the three of us settled down to grilled cheese sandwiches and milk. We held a luncheon postmortem on the morning's accomplishments and agreed that the hardest job remained. Elliot was thoughtfully silent as he downed 3 sandwiches which he chased with 2½ glasses of milk.

Returning to the task at hand, I climbed back up the tower and shouted down to Elliot and Jim to make the rope taut while I unwired the top section. As the assembly swung free I heard a distinct grunt from below and realized that the boys were having a bad time holding on. I was watching a double hernia in the making as they groaned, inching the assembly as the rope strained. We discovered that the top section was tied too high up with the gin-pole rope and it had to be brought back down to the ground and retied. By the time we were finally done I was literally shaking from exhaustion and hated myself for not having tackled the job in a normal manner. My ground crew had a few ideas about my engineering ability too, I'm sure.

I'd like to say that this was the beginning of DX and solid QSOs but that isn't how it went. A shorted coax connector (because of a hasty solder job) necessitated three more trips up the tower in successive days. Despondency was the prevailing mood until the trouble was discovered.

But was it worth it? Does 10 ft make a difference? Would I do it again? Yes, yes, yes. But not *that* way!

. . .K9PYY■

A TRANSISTORIZED 10 METER DSB TRANSMITTER

by Roland L. Guard, Jr. K4EPI

The DSB transmitter described herein uses crystal control and runs 1 watt or so, which can be used barefoot or to drive an rf amplifier.

The unit should be assembled in a small minibox or built on perf-board or PC board and then installed in a small minibox, as stray hand capacitances can upset the carrier balance.

The transmitter consists of speech amp, carrier oscillator, balanced modulator, and PA stages.

The amount of carrier suppression available with a diode-type balanced modulator is −40 dB.

Care should be taken in selecting the diode pair. Check the forward resistance of several diodes with your VOM until you find two with the same or nearly the same forward resistance. Germanium diodes were used in this unit which were in a grab-bag pack of 50 for $1 from Poly-Paks. The diodes should read at least 10:1 (forward-to-reverse resistance ratio).

Capacitors C2 and C3 are 30 pF variables. Cb is a variable, and capacitor C1 is a 4–30 pF trimmer. Coils L1, L2, and L3 are ¼ in. slug-tuned types removed from a TV PC boards many types of these coil forms

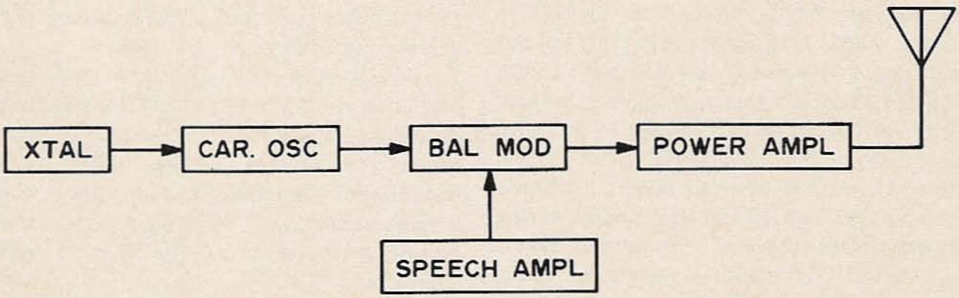

Fig. 1. This block diagram shows the simplicity of the homebrew 10m DBS transmitter. The tenth-watt unit can be used to drive a low-power linear or, for QRP fun, it can be used barefoot.

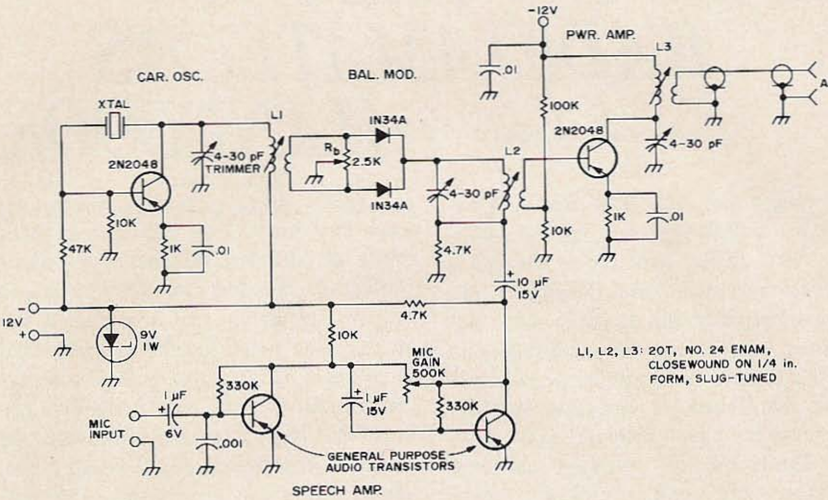

Fig. 2. Schematic diagram of DSB transmitter for 10m.

were tried and, although the ferrite slugs vary in Q, all coils resonated at 10 meters by juggling the slugs and tuning capacitors settings.

After checking the transmitter for operation by listening for the signal on a receiver, peak L1 and C1 for maximum S-meter strength. Then null out the carrier (minimum S-meter indication) with pot R_b. L2 and C2 may also be varied to null out the carrier. With the carrier nulled out, speak into the microphone with the mike gain control half open. You should be able to hear the double-sideband signal in your receiver. Next adjust L3 and C3 for maximum output.

At the home station, I use an RCA WO-88A oscilloscope to monitor the 50 kHz i-f strip in my Mohawk receiver. Observing the scope with the signal tuned in on 10 meters makes balancing the carrier a cinch. If you don't have a scope, monitoring your S-meter is sufficient.

On my scope, the carrier suppression of this transmitter is sufficient to put it way below noise level on the 10 meter band.

The carrier balancing adjustments should be carried out with the rig installed in its minibox, cover on. Small holes should be drilled in the appropriate places for adjusting the coils and trimmers. Changing crystals may upset the carrier balance and you will have to make the balance adjustments again. A few times and this becomes child's play.

Today's receivers can receive a DSB signal with no difficulty. Most of the time, operators will not be aware you are using DSB. This rig could easily drive a 6146B which would give you about 100W PEP.

This rig can also be used on any other band by changing the coils and crystal. To do this, "borrow" coil data from other published articles for the band you want. A homebrew vfo could also be built for this rig. This rig could be made into a walkie-talkie or hidden in the glove compartment of a car. It would be just the thing for talk-in at hamfests.

You can squeeze more power from Q2 by reducing the resistor values shown or by applying more voltage to Q2 collector (not to exceed the rated voltage for the particular transistor you use). However, you could also drive Q2 into a nonlinear operating condition. For DSB, as in SSB, you must operate the PA in its linear operating zone.

By turning the R_b balance pot to either side, you can use low-level AM. K4EPI■

REVIEWING THE 1971 RADIO AMATEUR'S HANDBOOK

Douglas Stivison WB2MYU

You might say that The Radio Amateur's Handbook is crystal controlled – very little drift from the standard. Year after year the Handbook appears with basically the same format, pictures, tables, and charts. As a guide to the avant-garde in ham technique and construction, the Handbook is certainly lacking. Yet it remains the cheapest and most popular handbook of standard amateur construction and communication techniques.

I built my first CW rig from the Handbook, and my first VHF project, and my first homebrew test equipment, and I used its tables to put up my first antenna, and to figure out the color codes on all those weird surplus components. Dog-eared and smudged illegibly on the dozens of oft-used pages, with burn holes from hot solder globs, and with schematics traced in pencil, my 1963 Handbook has been consulted countless times. I've built no less than six rigs from it. I've never purchased a newer Handbook because the book just doesn't change much from year to year.

However, I think I might invest in the 1971 Handbook.

The Handbook, printed this year on off-white nonglare paper, is not the guide for the experimenter using the newest components and techniques. Rather, it is a compendium of standard circuits and immutable tables and charts. It is the ham's, if not the engineer's, reference for the time-tested circuits and the time-tested techniques. The majority of its projects have been fabricated time and again by hams. I have never built anything from the Handbook and had it work the first time – but every project has worked eventually. For the standard Q-multiplier, mixer, modulator, oscillator, or power supply circuit, the Handbook is the reference. Certainly it is not the only source for these standard circuits, but it is undoubtedly the least expensive. For $4.50, you get hundreds of circuits, dozens of construction projects, tube and transistor tables, chapters on setting up and operating a station, and a guide to reasonably modern building techniques. The Handbook is a long-term investment which will probably provide both the Novice and the oldtimer with a pretty complete reference library for general construction techniques, tube troubleshooting, and ham operating. It is unquestionably still CW, HF, and tube oriented; but it provides adequate, if not extensive, coverage of most ham techniques.

For those long-familiar with the Handbook, the 1971 version will not be any earthshaking break from the past but will show a healthy and immediately apparent infusion of solid-state circuitry and theory. The groups of construction projects in each chapter do rely heavily on transistors and diodes and even ICs. But the book does not ignore the experimenter with his huge tube junkbox. True, tube projects end up too big, too hot, too heavy. But to the fellow with the well-stocked junkbox, the disadvantages are worthwhile tradeoffs for expense. Tube projects can be cheap, cheap, cheap if you've a 10-, 20-, or 30-year accumulation of tubes, sockets, and junkbox parts.

There are all the familiar charts; and the transistor tables have been expanded although they are still lacking in breadth. A few of the old standby projects were deleted and a few new projects were added. If you buy new Handbooks as infrequently as I, this is the greatest bargain going at 50¢ a year. Even if you buy your Handbooks more frequently, it is still one of the few bargains around today. And for the radio beginner, it is an essential one-volume reference library.

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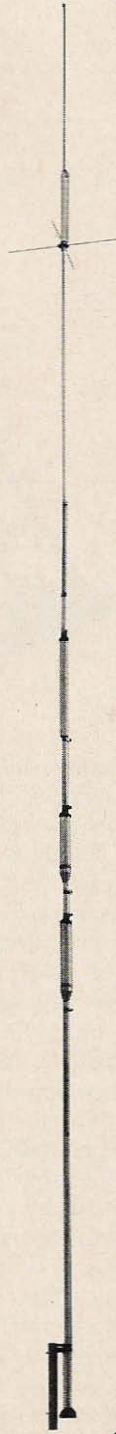

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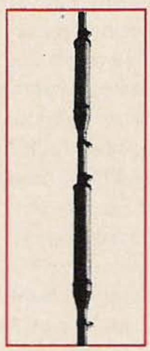

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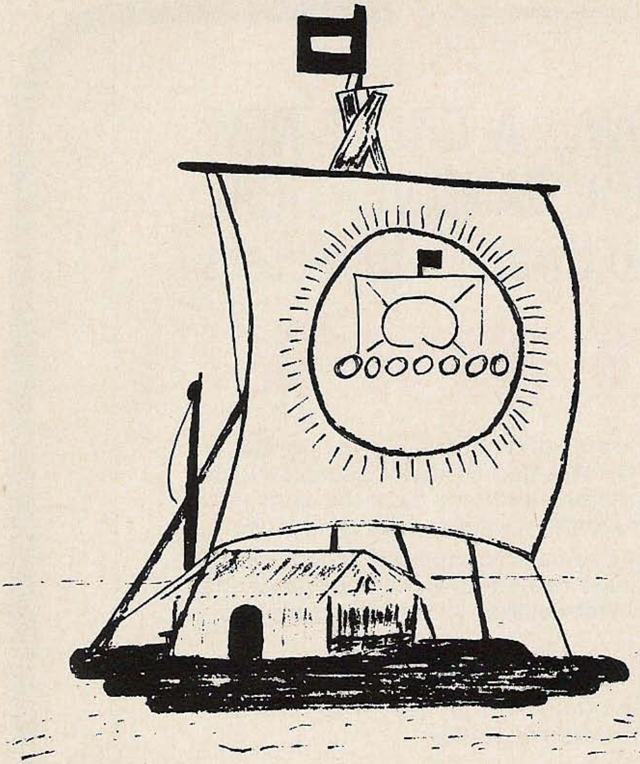
A journalist tries for a scoop on La Balsa, and gets put . . .



ON THE SPOT

by Alan Shawsmith VK4SS

It was midday in Brisbane, Queensland, Australia. The place had gone plain crazy. The reason being that the *La Balsa* raft had at last been sighted. How such a primitive craft could have survived the many cyclones and reefs on an 8500-mile drift from Ecuador was past understanding.

My shack was a bedlam of noise and voices. The ham band receiver was turned well up on 13100 kHz where the VKs were concluding their assistance operation in cooperation with Emergency Air/Sea Rescue. From a broadcast set a local station repeated flash items on the raft's progress. The portable TV set was telling the viewers to stand by for scoop pictures. My telephone rang incessantly.

The door burst open and in rushed a buddy. "Hey, Al, I've got an assignment to cover the raft! It's fair dinkum. She's only a few miles off shore up the coast a bit."

I pointed to the TV where the first aerial shots were on the screen. Together we gazed in silent admiration and awe. There she was; a charcoal chip of a ship with a pocket hanky sail and bobbing pertly in a turquoise sea. From it four heavily bearded young men waved madly.

"Gosh," said my friend, Bob. "How'd they keep that tied together? I can't even make my kids' balsa planes stay put."

I turned down the receivers and we got to business. "Now listen, Al," he said. "You're gonna do a story on this, too, aren't yer? Well, let's combine – 'cause I need some help. You've all the knowhow to cover the ham angle and I've got all the gear for photos."

"Okay, it's a deal, but don't be too cocky about making the scene. Customs and quarantine officials are going to keep the raft anchored out in the harbor till they've done their routine on it. No one will get within shouting distance."

The lip of young Bob Harrow curled contemptuously and I remembered he'd been in strife with the Customs on more than one occasion. "That figures," he said.

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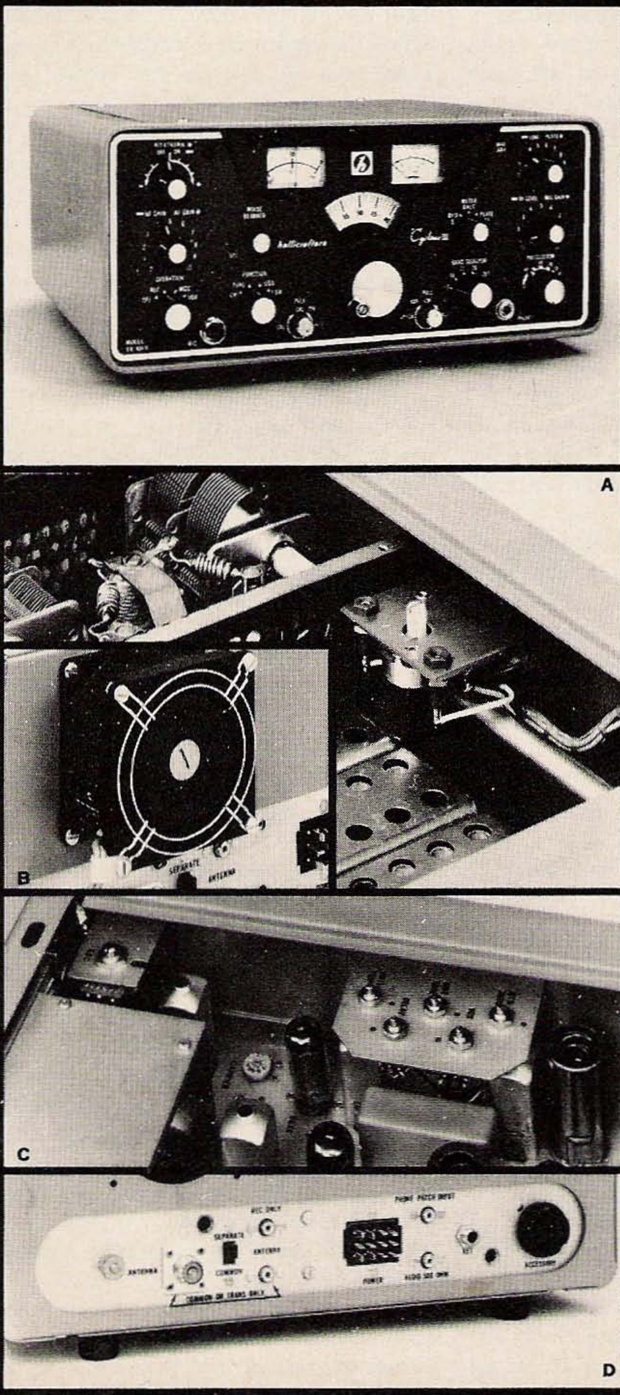

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"Just like their rotten form. It might take hours and while it's going on, some syndicated news medium will buy up the world rights and phut – that's it. The crew and the raft are in 'wraps.'"

"Well, regs are regs and – ."

"Yeah, but in this case they're red tape. What do the Customs johnnies think they're gonna find? Opium, by raft from Ecuador! – that's a laugh." Into the face of my young friend came a look I feared. Bob made each assignment a life-or-death challenge. We'd been out news-hunting before and the overenthusiasm he displayed at every obstacle quickly gave me a case of the shakes.

"Maybe it's best to wait till some of the hysteria and shouting has died down. Then we can have a look at the raft and – ."

The suggestion was brushed aside. "Al, you want pictures, don't ya? This means we gotta be on the spot, man. Right on the spot and organized, do yer hear? He made a gesture of impatience.

"The ETA happens to be around midnight. Not the best time to interview VIPs and take photos of the raft."

"It'll be a gas, man. I'll bring all my flash and color gear. You can have the tape recorder and we'll toss in my wet suit just in case."

"You mean – ."

"Yeah, I'll swim out to the raft if I have to."

" – and the gear."

"Let's worry over that problem if it arises."

* * *

We roared out of Brisbane on the 80-mile sprint up the coast to the usually sleepy small boat harbor of Mooloolaba. It was also the base from which ship pilots and customs and quarantine officers operated. "We've gotta find out just where they're gonna anchor that raft," Bob kept repeating. "We must be right on the spot or it's no go."

What a sight met our eyes. Never had this small village seen such a crowd. Like most uninformed mobs, they milled everywhere. The jetty, with its spindly legs, must surely collapse into the sea from the sheer weight of those struggling to get on it. There were TV camermen, announcers, technicians, reporters, journalists – the lot; you name it.

Bob leaped into instant action. "Al, you stay here and keep tabs on the gear and I'll mosey around and see what can be drummed up on the raft. It was two hours before he returned; I was getting anxious. There was alcohol on his breath and a gleam in the sharp eye. He held up two thumbs. "She's apples, Al – the good oil!. Struck a lad from the quarantine section at the local. Cost me a few beers but it was worth it." He pointed past the jetty across the mouth of the wide Mooloolaba River. "There," he said. "But I'm not aiming to wait till she ties up and Customs take over. As soon as she crosses the bar I'll board her myself."

"But that's a mile out."

"I've got my wet suit, snorkel, and goggles and now I'm off to find and hire a boat."

"How will you get past that?" I pointed to a searchlight being erected in the Customs enclosure.

Bob's lip curled again. "I'll see yer later. Oh, if yer need a drink, you'd better lock the car and make a dash for it, 'cause we're gonna have a pub with no beer soon. The news hounds are drinking it dry. There's another semitrailer load of the stuff on the way, but when it'll get here is another matter. He vanished into the crowd.

My mouth was dry but I resisted the temptation. Time enough for a quiet noggin when the action was over. Cars continued to stream in and small boats appeared from everywhere. More than once I heard a youthful shout. "Row you out to the raft for 40¢ a head, mister." The local kids weren't missing a trick.

This time it was dark when Bob returned and in a crestfallen mood. "Not a hope," he said miserably. "The 'scalpers' are in. They want a mint to row a yard. But I'm not licked yet, Al." There's a couple of boats in a little cove upstream. Let's take a look-see."

Very reluctantly I climbed into the car. Bob's impetuous determination might well lead us to disaster rather than a scoop.

Neither boat had oars and one was chained to a tree. The other was a tiny flat-bottomed plywood affair.

"Perfect," said Bob, eyeing the flimsy shell.

"For what?" I said sourly. "Both of us in that plus the gear and it'll sink. My bath back home is bigger."

"The tide's against us and as there's no oars, I'll swim behind and propel you with my flippers. Don't worry, she won't sink."

"Bob," I said pleading. "You know I'm a lousy sailor; as soon as we hit the open water I'll need a seatbelt and a paper bag." I cast a fearful look back through the trees to the house on whose property we were trespassing.

Reading my thoughts, Bob said, "Don't panic, we'll return the boat and no one will know."

"That's your view, but to the owner, it's thieving."

"Look" said my mate, getting impatient. "It's our last chance. Hop in and I'll get the gear."

"No, not in that bloody bit of bark."

We stood, both angry and in silent disagreement. Finally Bob said, "I'll go it alone." Quietly, he slipped into the water suit and prepared to cast off. At the last moment and without a further word I stepped into the oversized tub and we were away.

* * *

The trip to the raft's place of anticipated anchorage went off better than expected. We crept along close to the far bank where there was little current and darkness hid us from the glare of lights opposite.

"See, what'd I tell yer – a piece of cake," said my energetic cobber. He glanced at his watch and pointed in the direction of the distant murmuring surf. "See, there they come."

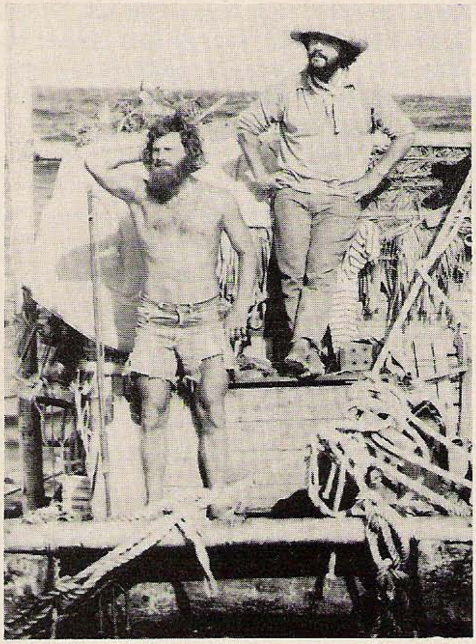
The tow boat approached and slid past and then *La Balsa*, with a lantern at the masthead, nosed gently and quietly into slack water. Instantly, a light from the bank was thrown on her and I could see movement in official quarters. We were alongside in a matter of seconds. There was a trace of surprise on the crew's bearded faces as Bob rose from the sea in his goggles and black wetsuit and leaped on board. All arms were instantly extended in handshakes. Congratulations, congratulations. Some photos, please, we requested. Capt. Alsar Vitalu (HC9EBP) was in the act of covering up the Hallicrafters SR150 with waterproof sheeting; he obliged by posing at the transceiver. In answer to my questions he said the equipment was okay except for the microphone; and the rig would load 110 watts into the vertical antenna. He wished to thank the VK hams for their vigilance and help. Bob was hurriedly adjusting his gear, clicking his cameras and cursing the moving searchlight for spoiling his shots.

A flotilla of small boats streamed out from the jetty and the fast Customs launch zoomed from its moorings. We pitched the tape recorder and gear into the little plywood dinghy I ducked into the reed-thatched cabin to congratulate again and thank the smiling, courageous captain and crew. It was then I spotted Minette, the ship's black and white cat. She crouched in a corner, terrified by the sudden strange intrusion and noise. I'm the world's greatest sucker, when it comes to animals. Stepping slowly forward, my arm went out to gently stroke and calm her. At the same instant, a hand fell on my shoulder and a voice demanded, "Who are you! No one's allowed on board until it has a clearance. I see you were fondling the cat and it has to be quarantined."

It was time to quit the scene. Bob had already left the raft. I made to follow but the Customs officer barred the way. "You'd better go aboard the launch," he said.

"But," I protested. "We're journalists and only came for pictures." Anxiously my eyes searched for Bob but the little boat had already slid into the darkness. The arm of authority remained pointing, so I did as requested. My cobber had insisted we be first on the spot. Now it seemed I really was *on the spot,* and likely to be quarantined along with Minette the cat.

The armada of small rowboats had reached the raft and confusion mounted. Propelled by the herd instinct, the pleas of



Bob tried hard for one good photo of La Balsa and her crew. This wasn't it, though. This excellent shot was snapped by the "Telegraph," a Brisbane newspaper.

the police to stay away from *La Balsa* went unheeded. People of all kinds clambered to get on board. There were shouts of welcome and congratulations. For a time it seemed the forces of law and order would lose the battle to keep the raft from being swamped. However, finally the tumult died. Customs completed their check and the launch returned to the quarantine station. The four trans-oceania adventurers were taken ashore to the local yacht club where an official reception, open to all, was to be held.

But not for me, alas. I was led to a large sparsely furnished room and handed a dressing gown, some six sizes too big.

"What's this," I said testily, "a tent?"

"Remove your clothes and put it on," said the officer.

"What for?" The distant sounds of repeated cheering and the singing of "For They Are Might Great Fellows" reminded me of what I was missing and pricked at my temper.

"It's the regulations for contanimated clothes – until the Doc clears you. But right now he's busy."

"Look," I said, trying the bluff that he who hollers loudest is often served first. I'm expected at that reception at the clubhouse. The Skipper of *La Balsa* is an amateur radio operator and there are other operators there waiting to extend an official welcome on behalf of our fraternity.

"Is that so?" He was completely untouched.

"Yes it *is* so, and I demand a clearance – now!" With a faint smile of contempt, he disappeared.

Realizing that further kicks at the Establishment would only result in a stubbed toe, I began to disrobe. A brusque but genial MD strode into the room.

"Oh, hullo there; sorry about the delay, old chap. No need to put you on a spot like this (the phrase was beginning to irritate) but precautions must be observed, you know. Just had a look at Minette myself. Cute cat. Love animals. Pity she has to be isolated. Well, now, no need to keep you." He pointed to a door across the hall. "Have a brushup in there before you go – cheers." He was gone.

* * *

The festivities were over when I reached the clubhouse. The early dawn light began to cast weak shadows. After a hero's welcome the four sailors had been whisked away and gone into smoke for a long overdue rest. I marveled at their tremendous physical condition and how they'd maintained it for so long in their primitive craft. Under a tree Bob's car was parked. He was nearly asleep and rather alcoholic.

"Sorry," I began.

"So you should be. Fancy getting trapped like that. I was about to come down and try and spring yer." He held up an unsteady hand. "Boy, what a night; I got some more photos and ran a bit more tape – if yer can hear it through the bedlam. He reached into the glovebox and produced a small hip-sized flask of brandy. "Your particular choice, huh!"

"How'd you manage – ?"

"Ssh. It's on the house."

"Bob," I said, "what would I do without you."

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FM FM FM WALKIE TALKIE

Transceiver Directory

If you are seriously thinking about adding a walkie talkie (hand-held) transceiver to your 2 meter FM system, but confused by the many types of units and wide range of prices, I think this article will help you make your final decision. The advent of repeaters and the convenience of carrying around a small transmitter with a range of 50–100 miles makes the purchase of a walkie-talkie tempting indeed. Our company spent several months collecting information on all the VHF (high band) commercial two-way radio systems, including walkie-talkies, so that we could make the proper decision on purchasing the right equipment. Because we, like the amateur, were interested in getting the best value for our dollar, we tried to evaluate the tradeoffs of performance versus cost. Our research is summarized in the "High Band FM Walkie Talkie Comparison Chart" and the following paragraphs. The chart is arranged, from top to bottom, by retail cost (including the cost of a rechargeable nickel–cadmium battery). Information presented here is from manufacturer's literature and interviews with manufacturer's sales representatives. We hope the readers of 73 Magazine will benefit from our research.

VARITRONICS HT-2; Varitronics, Incorporated, 3835 N. 32nd St., Suite 6, Phoenix, Arizona 85018.

Originally marketed as the TELCO HANDICOM (see the performance review published in Volume 3, Number 6 of FM Magazine), this is a Japanese import reportedly exceeding the specifications shown on the chart. Already relatively low-priced, the HT-2 comes with crystals, nicad batteries, charger, earphone, carrying case.

JOHNSON MESSENGER 540; E. F. Johnson Company, Waseca, Minn. 56093.

This is probably the most inexpensive of the American-made walkie-talkies. A nice feature is a nicad battery that doesn't need a charger, just remove it from the bottom of the transceiver and plug it into any 110 volt ac outlet for about 1½ times the hours it has been used. With most chargers costing about $10 to $40, this is a good

savings and you don't have to lug a charger around with you.

SONAR 2301; Sonar Radio Corporation, 73 Wortman Ave., Brooklyn, New York 11207.

One of the few radios with a steel case, for rugged use. We hear that the component layout makes repair work easier, also.

UNIMETRICS MINIVOX III; Unimetrics, Inc., 39 Werman Court, Plainview, New York 11803.

Another Japanese import that looks very much like the Motorola HT 200. Aerotron also markets the same transceiver.

HALLICRAFTERS FM-1; Hallicrafters Co., 600 Hicks Road, Rolling Meadows, Illinois 60008.

Probably the most rugged of the lot. Its large size accommodates batteries that let it work for 40 hours with nicads, and even longer using standard D-size flashlight batteries (which are easy to buy anywhere). We've heard reports of the transceiver still working after such abuses as being run over by cars and rolling down hills.

MOTOROLA HT-100 (H13FFN); Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Schaumburg, Illinois 60172.

The lightest transceiver of the lot, with easily a couple of hundred milliwatts of rf power output (though it's rated for 100 mW). Extremely sensitive receiver. It does a great job where a good repeater is within range. Very tiny (fits into the pocket). Expensive; also no mercury or alkaline battery replacement is available.

HALLICRAFTERS "HAND COMMAND" HC-100.

Made with lightweight solid aluminum case. Accessory jacks have waterproof covers. Many accessory options.

COMCO MODEL 802 (or COM-PAL II); Communications Company, 300 Greco Ave., Coral Gables, Florida 33134.

This walkie-talkie is probably manufactured for more companies than any other; the same transceiver is made for Aerotron (Model DP15), RCA (Personalfone), and Radiomarine Corporation (see product review of page 30 of FM Magazine, Volume 3, Number 6). It is a completely waterproof walkie-talkie and its plug-in circuit modules make repair very easy. A 4W rf power output unit is also available.

MOTOROLA HT-220 (H23FFN and H33FFN).

The newest transceiver from Motorola and a true pocket unit. Three models are available: standard, remote, and universal. The standard unit does not have an external microphone and is about $100 cheaper than the price shown on the chart. The remote unit has an external microphone/speaker (no speaker in the unit itself), its price is the one shown on the chart. The universal unit has an external microphone, but a speaker in the unit. A 5W unit is also available. Note that you can have as much as 5 MHz frequency separation without degradation, important for repeater users. A special charger allows 100% charge in one hour! A rubber-covered coil-type antenna about 6 in. long makes out-of-pocket operation easier, but it's an accessory item.

BELL AND HOWELL KELCOM III; Bell and Howell Communications Company (Formerly Kel Corp.), 186 Third Ave., Waltham, Mass. 02154.

Another true pocket model, slightly smaller and lighter than the Motorola HT-220. It has a built-in compression circuit, which lets you talk while you keep the unit in your shirt pocket. A unique fold-over antenna enhances pocket operation.

GENERAL ELECTRIC MASTR PR36; General Electric Co., Mobile Radio Dept., Lynchburg, Virginia 24502.

This is GE's newest entry and the specifications look great. It has a voice-operated transmitter that allows true hands-free operation. Another good feature is a fast charger that provides a 70% charge in 15 minutes!

HIGH BAND FM WALKIE TALKIE COMPARISON CHART

MFR	BASIC PRICE ($)	RF OUT (W)	FREQ. ERROR (%)	SENS. (µV @ 20 dB)	SELEC. (dB @ 30 kHz)	INTER-MOD (dB)	AUDIO PWR (mW)	WT. INCL BATT (oz.)	SIZE, in. H	W	D	EXT. MIKE ?	TONE SQ AVAIL	MFR LOC
Varitronics HT-2 (2 freq)	269.95	1.6	0.002	0.4	−70		500	36	8.5	3	2	no	no	Japan
Johnson Messenger 540	425.00	1.5	0.001	0.5	−70	60	750	28	8.5	3.5	2	yes	yes	USA
Sonar 2301	402.00	1.6	0.002	0.5	−85		250	42	8	3	1.5	yes	yes	Japan
Unimetrics Minivox III	439.45	1.8	0.0005	0.5	−80		400	40	9	3.5	2	yes	yes	Japan
Hallicrafters FM-1	521.80	1.5	0.0005	0.5	−60		150	70	11.5	3	3	no	yes	USA
Motorola HT 100	528.00	0.1	0.0015	0.35	−70	50	200	15½	4	3	1.5	no	yes	USA
Hallicrafters HC-100	529.00	2	0.0005	0.5	−75		500	45	9.5	3	2	yes	yes	USA
Comco Model 802	565.00	2.2	0.0005	0.5	−80		750	30	8	3.5	2	yes	yes	USA
Motorola HT 220	647.00	1.8	0.0015	0.35	−60	50	500	21	7	3	1	yes	yes	USA
Bell & Howell Kelcom III	660.00	1.7	0.0025	0.35	−60		250	18	7	2.5	1	yes	yes	USA
General Electric PR36	790.00	4.5	0.0005	0.35	−75	60	500	43	8	3.5	2	yes	yes	USA
Motorola HT 200	762.00	2.0	0.0005	0.5	−70	55	500	40	9.5	3.5	2	yes	yes	USA

MOTOROLA HT-200 (H23DEN).

The workhorse of the walkie-talkies. There are probably more of these units in use than any other. Good specifications, many accessory options, and two-frequency kits (and a four-frequency kit for amateur use) still make this transceiver desirable. As newer units are put into service, more used HT-200s become available. (Motorola sells reconditioned units to commercial customers; Spectronics, Inc., near Chicago, sells used Motorola units to amateurs.)

We hope our research and this short summary will help you choose the right walkie-talkie for your VHF amateur system. More details and data sheets can be obtained by writing the manufacturers listed in the preceding summary.

. . . Ralston ■

an ADVANCED Preamp-Compressor Clipper

H.P.Fisher VE3GSP
1379 Forest Glade Road
Oakville, Ontario, Canada

After a thorough literature survey on speech compressors, I built several of the more promising circuits and compared their performance. After this effort, all preferable features were combined in a single unit. The "unit" can take low- or high-impedance microphones with outputs from 0.1 mV up and delivers a husky 40 mV rms output with a total compression of 30 dB for a 4 dB output change. Output noise is −35 dB without signal and better than −35 dB with an audio signal, thus there is no noise "rush" when your voice ceases.

Experimental

I built five preamp-compressor units over the last few months; one is the "Caringella" compressor, one by DJ6BV (DL–QTC), one by W2EEY (73), one from "Electronik," and one of my own design. Four of them are somewhat complex and use four or more transistors; they use a variable-gain amplifier which produces its own agc for gain regulation. The other one is a clipper-type preamp–compressor which has a smaller compression range and more distortion, but has low noise characteristics. I used a scope and signal generator to measure compression, sensitivity, noise, and distortion. Attack and release times were calculated from R and C values in the line. On the Caringella compressor, I noted insufficient gain for low-Z dynamic mikes, which could be obtained by changing the FET input stage into an amplifier rather than an emitter follower. The unit distorted on low tones due to its fast attack time. Noise output was low, but frequency response was much too wide, particularly below 300 Hz, where an SSB crystal filter can't do anything for you. The compression is 30 dB all right, but there was a 6 dB output change versus 30 dB input change, which could have been an anomaly of the particular unit I had.

The compressors by DJ6BV and W2EEY are similar in design and yield roughly 25–30 dB compression for 6 dB output change. Both units lack sensitivity and are noisy in speech pauses. Attack and release times were adequate and no noticeable distortion occurred. The unit from Electronik was specified at 40 dB compression, but I judged it to be a rather odd circuitry since gain control is achieved by resistive shunting in various amplifier stages; therefore, too many transistors were required. Also, the sensitivity was not adequate and, in order to change the frequency response, some component changes were necessary. The last unit, one of my early designs, is a two-transistor preamp with a clipper at the output. Though the output noise is very low, the compression range is 20 dB at the most for reasonably low distortion. This unit is very

New FM for '71 Standard's SR-C826M

professional quality, solid state, two-way radio, designed and sold exclusively for amateur use in the United States and Canada.

Standard Communications Corp., the world's largest manufacturer of marine V.H.F. equipment, has just developed a new industrial quality, high performance 2-meter unit. This rugged, compact transceiver is available only in the U.S. and Canada thru an authorized Standard dealer. The "826" is so compact that it makes mobile installation practical in almost any vehicle or aircraft, it becomes fully portable with the addition of Standard's battery pack.

GENERAL

Freq. Range — 143 to 149 MHz, 2 MHz spread

Supply voltage — 11 to 16 VDC. Negative Ground 13.8VDC nominal

Current Consumption — .15 amp receive standby. 2.4 amp transmit

Number of channels — 12-Supplied with 4 channels

1) 146.94 Simplex
2) 146.34/94
3) 146.76 Simplex
4) 146.34/76

Microphone — Dynamic

Dimensions — 6⅞"w x 2½"h x 9⅞"d

Weight — 4½ lbs. max.

Frequency stability—.001% (−10 to +60°C)

TRANSMITTER

RF power output — .8 or 10 watts

Output impedance — 50 ohms nominal

Deviation — Internally adjustable to ±10 kHz min. factory set to ±7 kHz

Spurious and harmonic attenuation — 50dB below the carrier power level

Type of modulator — Phase

RECEIVER

Sensitivity — .4 or less microvolts for 20 dB quieting

Squelch sensitivity — Threshold — .2 microvolts or less

2 MOSFET RF Amplifiers
1 MOSFET Mixer

Deviation acceptance — Up to ±15 kHz deviation

Spurious and image attenuation — 65 dB below the desired signal threshold sensitivity

Adjacent channel selectivity (30 kHz channels) — 60 dB attenuation of adjacent channel

Type of receiver — Dual conversion superheterodyne

Audio output — 5 watts For external speaker

$339.95 (complete as shown with microphone, built-in speaker and external alternator whine filter.)

STANDARD COMMUNICATIONS CORP.
World's largest manufacturer of marine V.H.F. equipment
P.O. Box 325, Wilmington, Calif. 90744 (213) 775-6284

small and can easily be fit into a transceiver. The power can be derived from B+ since it runs with 20–25V at 1.6 mA only.

Circuit Design

It was obvious that the "perfect" compressor had to combine all good features, among which are:

- Adequate compression range (25 dB minimum).
- Sufficient gain for all types of microphones.
- Low-noise output, regardless of gain state.
- Fairly low attack time, medium release time, and low distortion.
- Selective frequency response (preferred range 300–3000 Hz).

The first parameter seemed easy to meet. I chose the DJ6BV/W2EEY way since it was simple and very effective. I obtained a negative signal to change the conductivity of a silicon diode (D1). This permits ac bypassing at the emitter of an early amplifier stage. I chose an attack time of 100 ms, slow enough not to regulate on the sine wave slope of a 300 Hz sine wave. Adequate gain is available through the use of a field-effect transistor preamplifier stage. This FET runs with moderate gain and improves the signal-to-noise ratio considerably. A 0.1 mV (rms) input signal will yield full agc voltage if the volume is turned up fully.

At the output of the compressor, however, there is a 20 mV (p-p) of noise. This noise is reduced to about 0.5 mV after it passes the following clipper stage. The clipper will also cut excessive peaks which occur within the 100 ms of attack time of the compressor, and will improve the 6 dB constant output to 4 dB for 30 dB compression. The compressor has a bandwidth of 300 Hz to 100 kHz (–6 dB). After the clipper, however, the upper response drops off sharply above 10 kHz. You need not worry about the 3–10 kHz range; your crystal filter will not pass more than 3 kHz anyway.

Adjustments

I did all my adjustments and measurements with a Tektronics' scope. Using the mike, I could see how constant the output level was when I talked right into it or at a distance of a couple of feet. For a steady signal source, I used a signal generator which permitted me to check on distortion. An easier way of adjusting the unit is to use a tape recorder with recording meter or "magic eye."

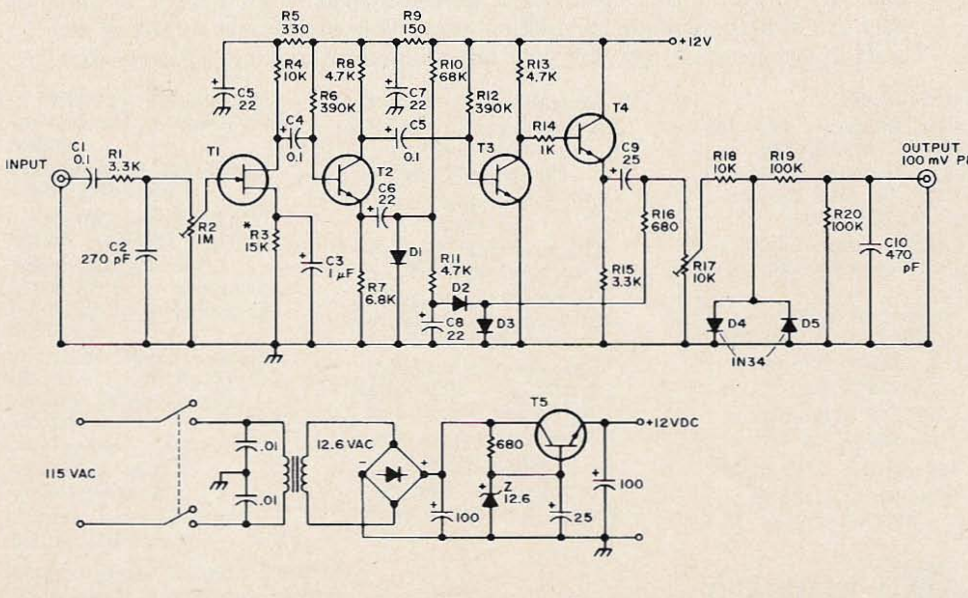


Fig. 1. Compressor schematic.

Power Supply

The unit requires 10–15V at 5–8 mA with low ripple. A battery can be used, but I preferred a simple regulated supply that operates from the 115V line.

The Speech Simulator

There are various ways of tuning the final stage of a transmitter or kW linear. For SSB, however, most hams take a deep breath and howl a long "aaah," trying to keep the loudness as steady as possible. Wave tones are rarely used since they cause about 4–5 times the plate dissipation on the final tubes than an "aaah." Most finals just don't take that for long. The speech simulator consists of a multivibrator which produces a 500 Hz square wave.

The square wave is integrated after it passes an emitter follower. The oscilloscope pattern of the derived signal is similar to that of an "aaah," and so is the power distribution. Since square waves are rich in harmonics, the latter are integrated also and such harmonic spikes are present up to a few thousand hertz. The generated tone is unique; it sounds somewhat like a ship's siren in heavy fog.

Occasionally, I use the tone to break in on roundtable QSOs when my voice doesn't do the trick. With this signal, you can run your final wide open without fear that you'll blow your tubes. The signal is also handy for antenna tuning – your own, or supplying someone else with a steady audible signal.

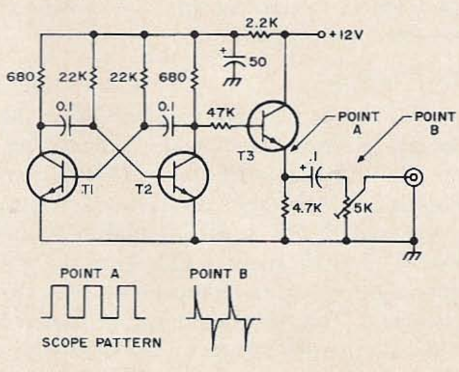


Fig. 2. Speech simulator schematic.

Conclusions

The compressor unit performs very well. I hooked it up to a tape recorder to check performance and quality of the audio. I could speak loud or gently, close or several feet away from the mike and still got the same volume out, audible or on the dB scale. The voice sounded clear, fairly light and of monotone quality. On the air, I demonstrated the unit to several hams. My set up enables me to switch from straight voice to a diode clipper and to the new compressor–clipper. A drastic difference in voice readability was reported, particularly when the signal was decreased to an S2 level on the partner's receiver. As to the cost: there are $18 worth of parts, plus a cabinet. An optional "speech simulator" tone generator cost me $5. The two units make a nice combined project which I rate worth the expense.

. . .VE3GSP

THE TRANSISTORIZED LM FREQ METER

A few simple modifications and you can plug FETS right into the tube sockets.

Charles Landahl W5SOT
121 Barranca Road
Los Alamos NM 87544

The last word may never be written about the BC-221 and LM frequency meters. The LM is particularly attractive because it is in the smaller package. With transistors replacing tubes, it has features most everyone wants – it is rugged, portable, and accurate, to name a few. I will describe a conversion of an LM-15 frequency meter in which field-effect transistors replace tubes; the power supply becomes a standard 9V transistor radio battery and the current drain is less than 3 mA when all functions are energized. In addition, I offer calibration information which will be of interest to anyone having a BC-221 or LM without the official calibration book. I bought an LM-15 for a temptingly low price (Fair Radio Sales Co., Lima, Ohio, $14.95). The set is sold in the "as is" condition with tubes and crystal but without calibration book. It is a good idea, but not necessary, to start with a set which is working before making the change to FETs. Resistance measurements will show if the circuits are complete. Important values are marked on the schematic of Fig. 1.

Smash Tubes

The most difficult part of my conversion was getting up the courage to smash the tubes! I wanted the bases for mounting transistors. Place the tubes one at a time in a paper sack, hold the top closed and with a metal object, strike the glass through the paper. The flying glass is caught and collected for disposal. Scrape and clean the mastic from the inside of the tube bases. Should you choose to mount a transistor socket in the wall of each tube socket, you can use the original wires; otherwise, unsolder the old wires and replace the needed ones with about 2 in. of sturdy new tinned wires. The appropriate tube base pin connections are shown in Fig. 2. Actually there is no preferred mounting scheme. Use whatever appeals to you.

Check for clearance between socket and walls. My conversion used transistor sockets mounted on metal plates which were bolted to the wall of the salvaged tube bases. This allowed FET substitution to determine which ones would work best in the several circuits of the LM. All FETs used are N-channel.

Modification

With cover removed and the LM in the upright position, front panel toward you, on the left side wall, look through two oblong machined slots and see mounted on a phenolic board a 50 kΩ plate resistor. Parallel it with about 6 kΩ. Turn the LM upside down, panel toward you. On the underside, two resistors must be shorted and a jumper wire made up and connected. Short R115, which is a 15 kΩ wirewound resistor, quite visible on a phenolic board at the left of the 1000 kHz crystal can.

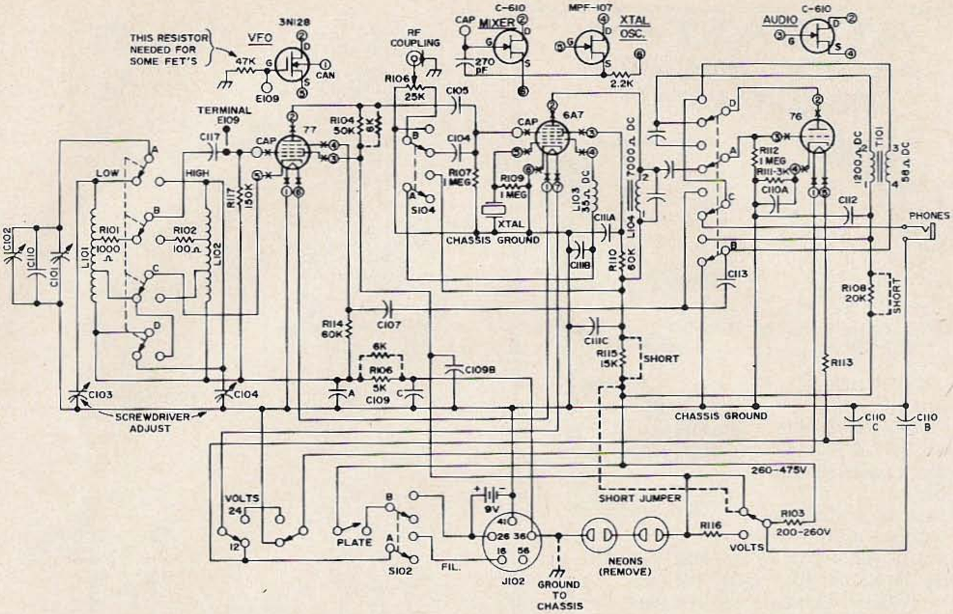


Fig. 1. Modified schematic of frequency meter.

Run an insulated wire from a terminal of this shorted resistor to the 260–470V tap contact of the link switch. This wire can be about 6 in. long and conveniently passes through a wall slot behind the crystal socket. The link switch and its terminals are on a phenolic board in the compartment aft of the crystal socket. The jumper wire will cross near the grid resistor, R109, of the crystal oscillator. While there, change the 100 kΩ (R109) to 1 MΩ. Next, unfasten the screws holding the phenolic board located to the left of the power plug. Tip up the board and short across R108. This is a 20 kΩ composition resistor which is in the plate voltage line to the audio amplifier. Also, at the power plug, locate pin 36. Short it to chassis ground. On most sets pin 36 is the ground return for the vfo cathode. The circuit was closed through external connections in a power supply. You have completed the surprisingly few changes needed to make the LM work on FETs and a 9V battery.

The VFO

With FET source connected to pin 5, drain to pin 2, can to pin 1 (if needed), plug the FET into the vfo socket. Connect a solid wire between terminal E109 and the gate of the FET. (Terminal E109 held the grid cap wire for the vfo tube.) Connect a 9V battery to the power plug pins. PLUS to 26 and MINUS to terminal 41. If you have a milliammeter in the battery lead, it should read about 1.5 mA when you turn on the FIL and PLATE switches. Provided you were fortunate in the choice of FET, you should hear a clear CW signal in your receiver. Set your receiver to 2 MHz or 4 MHz. You may need to connect a wire from the rf coupling post on the front of the LM to your receiver antenna. Rotate the LM dial between 0300 and 0600 on the readout. Your vfo will be on the low end of 125–250 kHz or 2–4 MHz depending on the position of the low or high band switch. The XTAL and MOD switches should be off. The FET selected for the vfo may require a 47 kΩ resistor between gate and chassis ground. I found this to be true for the RCA 3N128, 3N142,and *one* of the two 40559A FETs. On the other hand, one RCA 40559A and one of several 2N3085 silicon N-channel FET from Poly-Paks worked beautifully without adding 47 kΩ to the gate.

Apparently junction and insulated-gate field-effect transistors have slightly different characteristics which show up in this peculiar vfo circuit. My own choice is the 3N128 with the additional resistor on the

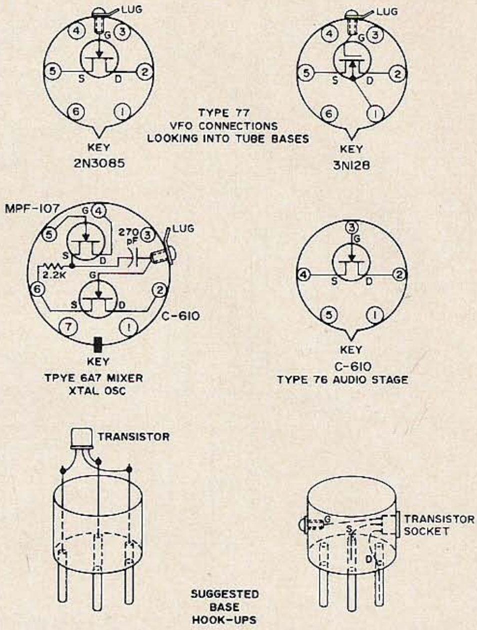


Fig. 2. Suggested semiconductor hookups for tube sockets.

gate. You may find it necessary to "tune" the source, drain, and gate resistances in order to have your vfo working well with a particular FET. I used potentiometers across the various elements to arrive at the recommended values. My vfo works reliably from 10V down to 6V and the maximum drain current is 1.5 mA.

Caution

Other oscillator hook-ups may occur to you, and they will work – but the tuning range and linearity of the vfo will suffer! Linear tuning is most important, so stick with that shown.

The AFO and AF Amplifier

The audio oscillator and amplifier wasn't as fussy as the vfo. I used a Radio Shack 276-664 FET – it is said to replace a C-610 or 2N3088. I found that the Poly-Paks "hobby" FET 92CU588 will work equally well. In making up the socket, gate goes to tube pin 3, source to cathode pin 4, and drain to plate pin 2. That is all there is to this one. Plug in the FET. When you next turn on the 9V power, the milliammeter will barely increase a few hundred microamps as you switch on the modulation control. At this moment a rather pleasant 500 Hz tone will appear on the vfo frequency no matter which harmonic you have tuned in on receiver. Your modulator is finished. The audio amplifier is too, for that matter. You just won't hear anything in the headphones untill you complete the crystal oscillator and the mixer circuits.

Crystal Oscillator

The reference oscillator is not much trouble. You have already changed the gate resistor from 100 kΩ to 1 MΩ. Actually this change may not be necessary because some crystals are more active and will oscillate well with the original resistor. Mine went into oscillation better with the higher value. The FET you select for this circuit can be one of several. Mine is a Motorola MPF-107. I found the Radio Shack 276-112 and the Poly-Paks 2N3085 also work, but draw more current. Whichever you choose, the gate connects to base grid pin 5, source to cathode pin 6 *through* a 2.2 kΩ resistor. Drain hooks to plate pin 4.

Now, when 9V is turned on, MOD off, XTAL on, you should hear the crystal oscillator signal every 1000 kHz on your receiver. The milliammeter should increase about 1.5 mA or less when XTAL is turned on. If you don't hear the crystal frequency, bring the receiver antenna wire close to the crystal FET. We still haven't made the connection which adds the crystal-oscillator signal to the rf coupling post on the front of the LM. Assuming you have all circuits in working order up to this point, we move to the mixer.

Mixer

There is no single FET substitute for a pentagrid converter tube. The dual-gate MOSFET comes closest; however, use of one would have defeated my goal of simplest conversion. Therefore, four N-channel FETs are needed to do the work of three tubes, but what a saving in power supply! The mixer concerns itself only with beat frequencies occurring between the reference oscillator, vfo, or an external signal – all audio work. Thus, a hobby

FET was selected. I used the Poly-Paks N-channel FET. A Radio Shack C-610 replacement will also work. Connect source to chassis ground through pin 6 of the tube socket; the drain connects to plate pin 2, gate to mixer grid cap wire through the lug in tube socket wall.

Finally, connect a capacitor (200–300 pF) from the top of the 2.2 kΩ crystal oscillator source resistor to the gate of the mixer FET (grid cap wire). You are in business.

With 600Ω phones plugged into the LM, you should hear all the necessary beat frequencies occurring between the vfo and the crystal oscillator as you tune the vfo through its range. XTAL must be on and the MOD switch off. Otherwise, the audio amplifier becomes the modulator and you hear nothing in the LM phones.

What Next?

With the beat notes loud and clear you are ready to calibrate. This is quite the most fun part of the work because the linear tuning rate of the LM is almost unbelievable. The slow rate is due to the series combination of the A section of C109, C101, tuning L101 or L102. The amount of the matter is that one revolution of the 100-division circular dial produces about 3 kHz change on 125–250 kHz range, and about 50 kHz per revolution on the 2–4 MHz range. The actual calibration of my unit was 2.89 kHz and 45.17 kHz per revolution.

The linearity can be checked by how little you need to vary the "corrector" for each zero-beat checkpoint. Each LM or BC-221 will be slightly different. Now, when you consider that the vernier allows you to split one division into tenths, then it is clear that you can set a frequency to better than 0.5 kHz over the range of the frequency meter. May I repeat:

1 dial revolution of
100 div = 45.17 kHz
1 division = 0.4517 kHz
1/10 div = 45 Hz

Therefore, all you need is a checkpoint at which to zero the vfo and start counting revolutions, divisions and tenths of divisions to accurately set any frequency within the two ranges of the vfo. I found it useful to construct graphs on K&E 358 11L graph paper. The grid is 10 X 10 (per 0.5 in.). The paper has 20 units vertical and 30 horizontal. This allows graphing 100 division and leaves room for 10 vernier divisions on the right hand end of the paper. Use the crystal checkpoints listed in Table I to locate *your* dial settings. Once graphed, a frequency can be selected directly from the chart, or, depending on the accuracy desired, interpolated between checkpoints.

Table I. Crystal Checkpoints

KHz	VFO	XTAL	Approximate Dial Settings
Low Band			
125	8	1	0320
150	20	3	1192
166.667	6	1	1750
200	5	1	2935
222.222	9	2	3700
250	4	1	4647
High Band			
2000	1	2	0396
2250	4	9	0945
2500	2	5	1493
2750	4	11	1050
3000	1	3	2606
3250	4	13	3150
3500	2	7	3711
3750	4	15	4262
4000	1	4	4812

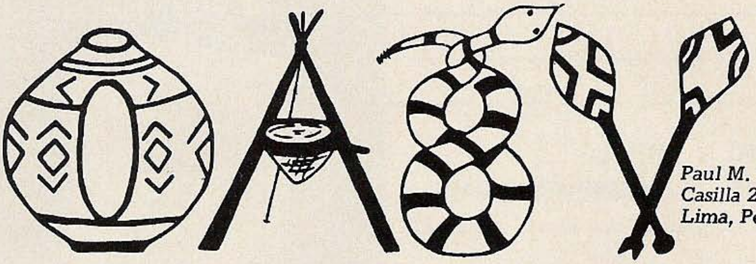
It is obvious from this discussion that the low band of the LM is fabulous. You can squeeze down to about 3 Hz by use of the vernier scale. By the way, hidden behind two cover plates just beneath the corrector knob, are "high" and "low" padder capacitors. These were used when vfo tubes were replaced to bring calibration book values into usefulness. The padders should be set near the middle of their range.

Make it Handy!

Fasten a handle to the case, strap on a 9V battery, go forth and have fun with your rejuvenated frequency meter. I use mine for its intended purposes as well as a band-edge marker and keying monitor.

W5SOT■

HAM RADIO, the BIBLE, and PERU



Paul M. Wyse OA8V
Casilla 2492
Lima, Peru S. A.

The following message was on the printer when I walked into the shack:

OA8G DE WA4ZRS
NR 662 WAXHAW, N.C.1230Z 22 SEPT. 1967
TO NORMA FAUST, YARINACOCHA, PERU
FROM VICTOR FAUST, WINDOM, MINN.
FATHER PASSED AWAY VERY SUDDENLY
LAST NIGHT. CAN YOU COME HOME?
LOVE,
VIC

Bible translator Norma Faust was in Naranjal, an isolated Amazonian Cocama Indian village about 250 miles north of Pucallpa, and there was no connecting road. Norma and her partner, Lucy Eakin, were there teaching Indians to read their own language which had only recently been reduced to writing. Would Norma be able to return home in time for her Dad's funeral? Thanks to amateur radio, there was a good chance she would.

Soon after the RTTY message was received, missionary pilot, Floyd Lyon (OA8AT) was flying one of our airplanes across the vast jungles to bring Norma in to our jungle base, Yarinacocha, where plane connections could be made to Lima and then on to Minnesota.

Norma, Lucy, and over 2000 colleagues make up a team of workers specializing in the task of analyzing unwritten languages, reducing them to writing and then translating the Bible for the speaker and reader of these languages. This team, known as the Wycliffe Bible Translators Inc., is presently working in isolated areas of 21 different countries. Radio communications are relied on heavily for the health and safety of the workers. Linguistic investigation and Bible translation in over 450 distinct languages and dialects is being carried on and with the help of many electronic devices, goals are being set to complete during this century the remaining 2000 languages still in unwritten form.

Of course, not all of us on the team are in actual linguistic and translation work. I am a radio operator and spend much of my time operating a net of some 20 battery-powered SSB transceivers, which our linguists use in the isolated Indian villages. I find the operation of this net, which meets on the assigned frequency of 5340 kHz, to be very challenging and rewarding. For our linguists it is a vital link with civilization.

Many times the linguists out in the tribe request phone patches with our base doctor to seek advice on the treatment of snakebite or a bad cut. There have been times too, when radio has saved the life of a member of the translator's family, such as when a child got into a bottle of aspirins or when another inhaled a near lethal dose of kerosene.

Radio not only provides needed communications to remote jungle villages, but it also is the lifeline for our pilots as they fly thousands of hours over the jungle, much of which is still uncharted.

Jungle Aviation and Radio Service, known as JAARS, is the technical service arm of the Bible Translators. Communication service is provided to many of the remote and uncivilized Indian villages with an international network of over 150 battery-operated transceivers. Among the more than 75 highly trained personnel of JAARS serving as radio technologists, radio operators, aircraft pilots, and mechanics, there are at least 32 radio amateurs signing such relatively rare prefixes as ÇP8, HC7, OA8, HK3, and VK9.

Bill Sasnett (WØTEM/4) is the director of the radio department at our JAARS Headquarters near Waxhaw, N. C. Here Bill directs a three-month concentrated training and orientation course for all new radio members to better prepare them for their work in the remote areas of the world. In addition to the three months spent in training at the JAARS center, each trainee takes three months of jungle survival training in Mexico.

At the JAARS center one also finds amateur radio playing an important part in the operations. The WBT club station, WA4ZRS, is used by the licensed hams working or training in Waxhaw. WA4ZRS is, likewise, net control on a daily traffic net operating on 21.360 MHz between 1400Z and 1500Z to handle traffic with the different countries where third-party traffic is permissable. The 15 meter net is useful in keeping contact with our different fields, and also serves as a practical means of training new members which will be useful to them on the field.

Yarinacocha is one of those jungle outposts where overgrowth is too thick for a landing field. This PBY will settle for a stretch of placid water, though. Pilot is OA8AQ.

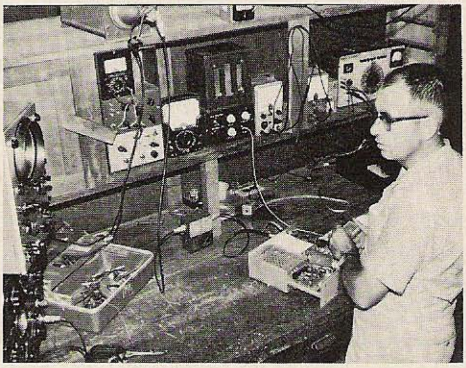
Omer (OA8G) checks the RTTY printout for news from the mainland. Ham gear keeps the Bible translators in effective contact with the outside world.

Since obtaining my first license (K4ASM) over 14 years ago, I have found many hours of pleasure and recreation in amateur radio. In addition to being a hobby, amateur radio also provides a real service, especially when one is isolated such as we are here at Yarinacocha.

I would like to express my appreciation to WB4IFK at the DUKE Medical Center in Durham, N. C., who maintains a faithful standby on 20 meter SSB and 15 meter RTTY to patch doctors throughout South America to medical experts providing unavailable counsel on medical problems in the jungles. This is a real service to all our health needs.

Amateur radio has also proved to be a big asset to us technically. Vic Poor (K3NIO) helped round up some surplus equipment and encouraged the use of amateur RTTY between WA4ZRS and OA8G. We have had very good success with an autostart RTTY link which is crystal-controlled on 21.100 MHz. This circuit has proved to be a real timesaver in handling much of the routine traffic for the 200 translators here in Peru. We have found 15 meters very reliable in providing communications to the eastern states during most of the daylight hours of the year. We hope that more of the South American fields will soon be able to join us on RTTY. I try to take a standby for breakers whenever I finish with the traffic at various times during the day. I have very little time to spend on RTTY outside of schedules but am interested in giving as many as possible an RTTY contact from the jungles.

In the past, the task of analyzing an unwritten language, reducing it to writing, and translating the New Testament has taken 20 years or more. The use and

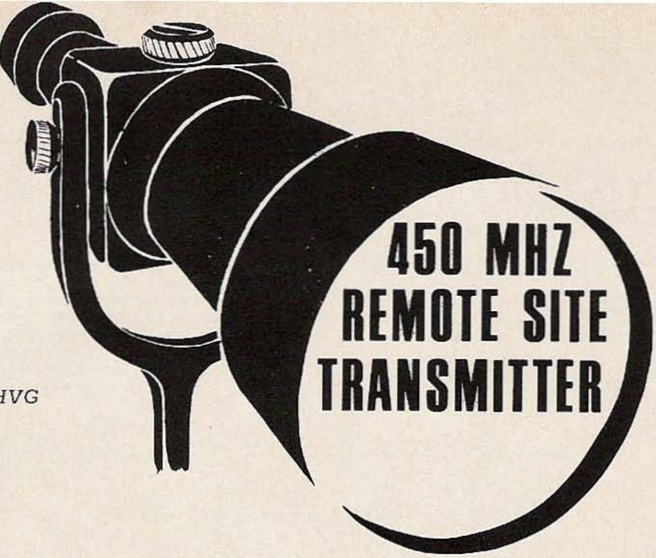


Paul (OA8V) tunes up one of the Pioneer 425 transistorized transceivers on 5340 kHz.

provision of radio and aviation has reduced this time considerably. Now Joe Grimes (XE1JJ) is experimenting with the use of Teletype, computers, and automatic typesetting equipment which could easily reduce the whole process to less than ten years.

As our linguistic and Bible translation work utilizes more of the advances in electronics, more technical missionaries will be needed to enable us to reach our goal of reducing the more than 2000 languages to writing. Besides radio technicians (minimum requirement: first class phone and general class ham ticket), pilots, printers, typists, schoolteachers, mechanics, and other specialized skills are being sought. As more countries make agreements for reciprocal licensing and third-party traffic, amateur radio will become more and more useful, not only for the safety and service but for the encouragement and technical help our hobby affords. A big thanks to ham radio, where fun and service have been combined for the world-wide benefit of many.

. . . OA8V ■



450 MHZ REMOTE SITE TRANSMITTER

Wilfred Collier WA1HVG
8 Packard Rd.
Peabody MA 01960

Many of the repeaters now being built are using 450 MHz for control or auxiliary inputs. Unfortunately, most of the gear available for use on 450 is either antiquated or expensive.

Both Motorola and GE use tubes in the power amplifier stages of these transmitters – tubes that cost many dollars each, and need replacement about once a year – or even more frequently, depending on use and power output. As this article will show, however, solid-state rf amplification just isn't all that hard to come by – simply "do it yourself."

The 450 band is looking more and more attractive for ordinary repeater operation nowadays, anyway – particularly in view of the heavy crowding in the 2 meter spectrum. Probably if more people were aware of the good coverage achievable on UHF, there would be a stampede for the 450 band by those closed repeater groups so active on VHF.

Path Loss

One factor that adds up quickly in the UHF spectrum is path loss. On 450 MHz, the ability to use a repeater 40 miles away just may be governed by how many trees your signal must pass through to

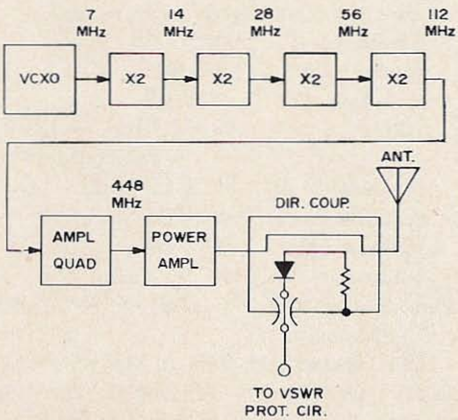


Fig. 1. Block diagram of 450 MHz transmitter.

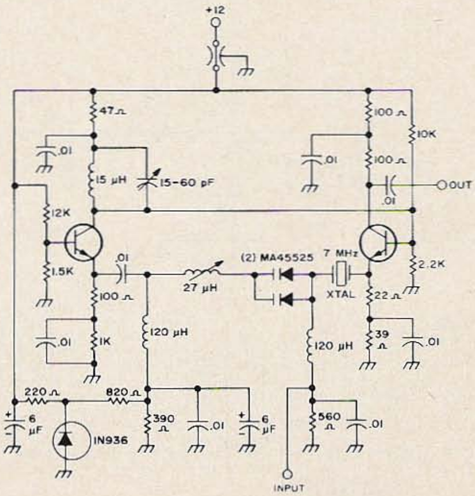


Fig. 2. Variable crystal-controlled oscillator circuit.

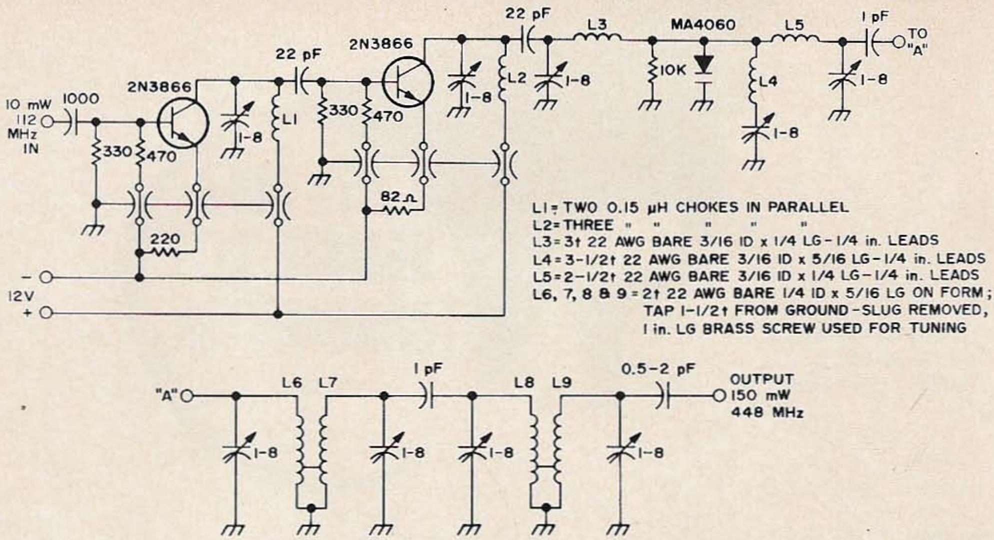


Fig. 4. Multiplier stages of transmitter. A 10 mW input signal is quadrupled to 448 MHz, at a power level of 150 mW.

reach the repeater site. The path loss on 450 is not greatly higher than that of the 2 meter band over average terrain for a given distance. To maintain a 99% reliability factor, the system must be set up for a 30+ dB fade margin.

Example: If the 450 receiver has a −115 dBm (0.4 μV) sensitivity for 20 dB of quieting and the transmitter is 40 miles away running 10W output (neglecting feedline losses and antenna gains, which ultimately must be added in), the fade margin is;

10W	= +40 dBm
rec. sens.	= −115 dBm
difference	= 155 dB
path loss	= 160 dB
difference	= 155 dB
fade margin	= −5 dB

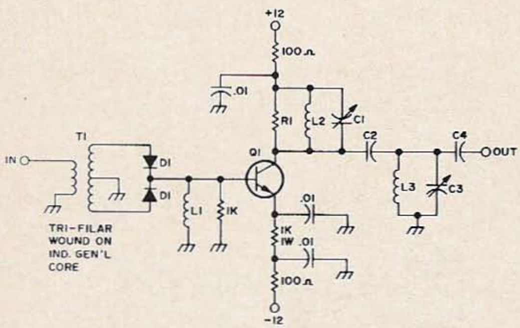
In other words you may *just* be able to use the system, but only occasionally will your signal be full quieting; most of the time you will be noisy into the 450 receiver.

Now let's look at an accurate case.

5W out	= +37 dB	
feedline loss	= 3 dB	
ant. gain	= 17 dB	
total	= +51 dBm	= 125W radiated power
Rx sens/20 dB	= −115 dBm	
feedline loss	= 3 dB	
antenna gain	= 17 dB	
total sens	= −129 dBm	

Fade margin = 51 + (−129) = 180 − 160 = 20 dB margin.

This means that 99% of the time your signal will be full quieting at the 450 receiver. I have purposely ignored antenna height gain, as this will vary considerably and is covered comprehensively elsewhere.



INPUT FREQ	T1 *	D1	L1	L2	R1	C1	C2	L3	C3	C4	Q1
7 MHz	6t-Q1 CORE	1N914	150 μH	15 μH	2.0K	33 pF FIXED	3 pF	6.8 μH	5-18	5 pF	2N3904
14 MHz	6t-Q2 CORE	HP2800	47 μH	2.2 μH	2.2K	10 pF FIXED	3 pF	1.8 μH	5-18	5 pF	2N3904
28 MHz	6t-Q3 CORE	HP2800	6.8 μH	0.47 μH	OMIT	8-25	1 pF	1.0 μH	2-8	3 pF	MPS918
56 MHz	6t-Q3 CORE	HP2800	3.3 μH	0.33 μH	OMIT	2-8	1 pF	0.15 μH	5-18	3 pF	MPS918

* INDIANA GENERAL CORE MATERIALS SHOWN

Fig. 3. Basic doubler block.

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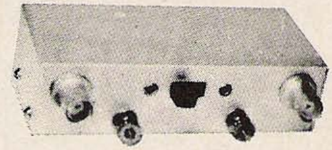

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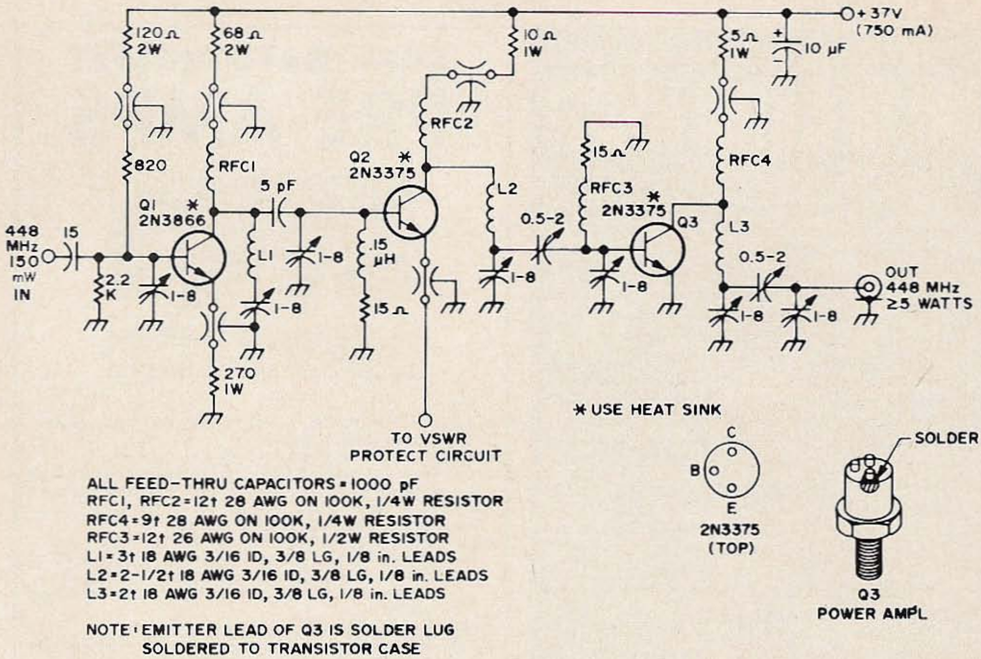

Fig. 5. Rf power amplifier stages. With a 150 mW input, a signal of at least 5W is produced.

Transmitter

As shown in the block diagram of Fig. 1, the design of this transmitter is straightforward; and it is easy to build and tune. Deviations from values upwards of 10% will not affect the operation; however, I do recommend that no changes be made in the type of transistors or diodes.

The oscillator (Fig. 2) uses a 2N3866 and a 2N3904 in an emitter-feedback configuration. The inductor in series with the crystal is used to match the output signal to the system receiver. The crystal should be ordered to operate in the "series resonance" mode. The oscillator puts out 10 mW. If the 390Ω resistor is changed to 270Ω this unit will drive a Gonset or any other small communicator.

The multipliers (Fig. 3) are push-push doublers, and need be tuned only for maximum output. Spurious responses measured better than 37 dB down from the signal in all cases when the multipliers were tuned for maximum output. Each stage is designed for a gain of unity so that the 10 mW power level is maintained throughout.

The power-amplifier quadrupler stage (Fig. 4) consists of two 2N3866s as amplifiers, a varactor multiplier, and a bandpass filter. The output of this stage is

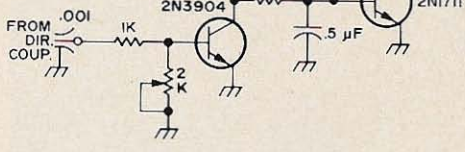

Fig. 6. Vswr protect circuit.

at the 100 mW level, and can be monitored on an FM receiver.

The final amplifier (Fig. 5) uses a 2N3866 and a pair of 2N3375s to achieve 5W output. A vswr protect circuit (Fig. 6) is included to add to the life of the output stage. The unit will not be damaged if the antenna is accidentally open or short-circuited.

Layout

All leads in both the quadrupler and the power amplifier must be *short.* I cannot stress this point enough. A ½ in. piece of 20-gage wire makes a reasonable choke at this frequency!

All of the transistors in these stages *must* have good heatsinks. I first built the unit on an aluminum box, and bolted a heatsink to the outside. Second thoughts were generated when I found out how hot things got after 30 minutes of operation. I suggest that the power amplifier be a separate unit built directly on a heatsink and not in a box.

Tuneup

Apply power to the oscillator only and check the frequency with a good stable receiver. The note produced with the bfo on should be pure and stable.

Apply power to each succeeding stage, tuning each for maximum power output. Output frequency should be checked after each stage is tuned. Each stage should be checked for stability after it has been tuned by removing the crystal from the oscillator. All output should disappear in all stages. If by chance it does not, isolate the problem stage and decrease the value of the collector resistance until it becomes stable.

The power amplifier should be tuned with only 20V applied at first. Tuning in these stages is affected by both supply voltage and drive level; 2–3W output should be seen with a 20V supply and 100 mW drive.

Directional couplers are covered reasonably well in the VHF manual. The only really critical part of the coupler is that it have sufficient directivity, or the transmitter will shut off. The coupler can be checked by using a 450 source such as a signal generator and a good load. Reversing the coupler should make an order of magnitude change in the voltage as shown in the diagram of Fig. 7.

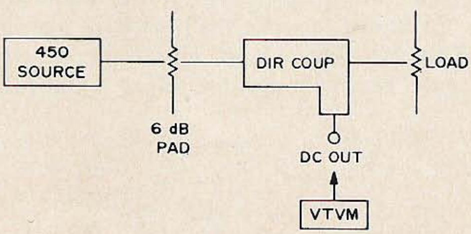

Fig. 7. Reversing the coupler should make an order of magnitude change in the voltage.

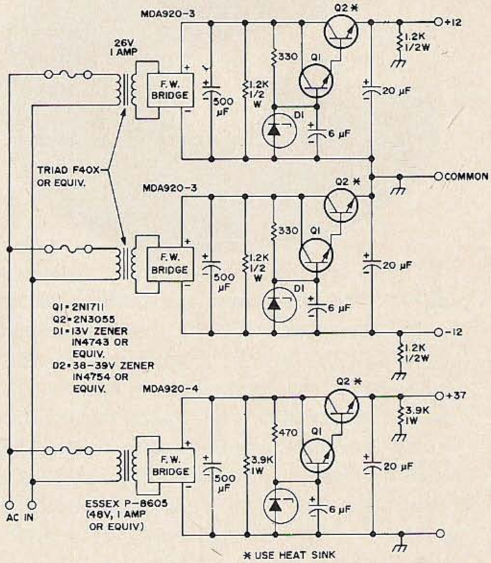

Fig. 8. Solid state power supply for 450 MHz transmitter.

Loads

If you don't have a good load for 450, then use 100 ft of RG-58/U and terminate it with a 2W 51Ω carbon resistor. This load will handle up to 60W input at 450 MHz! (There is a hidden clue about the line loss here.)

If built as described, this transmitter will maintain 5W output (continuous operation) for a long, long time. It should outlast any tube-type transmitter by a wide margin.

In the interest of completeness, I have included a power supply schematic (Fig. 8). This supply has proved quite adequate for the 450 transmitter, but it does require effective heatsinking.

I would like to thank Donald Sicard, Curt Seaton, George Meyer, and Norvill Staplefeld for their able-bodied assistance and incentive.

. . .WA1HVG■

THE S DERIVED FILTER

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If you are familiar with filter nomenclature you have come across the constant-k and the m derived, etc., but my favorite type filter, the "S" derived type really belongs to the ham. This is because "S" stands for surplus. The general truth is that many potential goodies are bottled up within black or gray cans gathering dust at your friendly local surplus house. The problem is how to operate on your potential treasure after you decide it has merit as the base for an "S" derived filter. In an attempt to light one little candle in the wilderness I will describe the events leading from discovery to successful utilization of the "S" derived whatzit.

A recent field trip to Fertik Electronics at 9th and Tioga here in Philadelphia turned up a typical low priced, gray boxed goodie. The markings indicated that it was

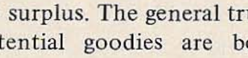

Fig. 1. Original circuit of surplus can.

a tuned circuit 288.0 Hz type manufactured by Raytheon. The diagram on the box showed a centertapped inductor with a shunt capacitor.

The first step in the operation was to rip off the top of the box. This disclosed a rather nice inductor of large dimensions shunted by a 0.047 μF transmitting type mica condenser. The dc resistance of the coil was about 120Ω.

Figure 1 represents the original contents of the can. Figure 2 represents the least complicated filter configuration that we can develop from our prize. Notice that the shunt condenser has been removed and put

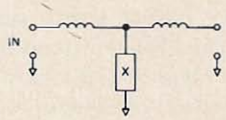

Fig. 2. Simple filter developed from contents of surplus unit.

into the satin lined junk box for future service. The block in Fig. 2 designated with an "X" is some type of frequency sensitive reactance still to be determined. Essentially the filter will be a frequency sensitive tee paid. The "X" which came out of my junk box was a 300 mH inductor. Using the test setup shown in Fig. 3, it was determined that a 0.1 μF condenser across this shunt "X" would resonate the filter peak around 900 Hz. The driving impedance of the audio generator shown in Fig. 3 is 500Ω as

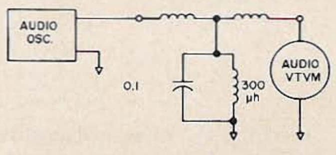

Fig. 3. Audio generator schematic.

-10dB	Peak Frequency	-10 dB	Load
875 Hz	900 Hz	950 Hz	Xtal phones
900 Hz	950 Hz	1200 Hz	magnetic phones

Fig. 4. Filter action for different headphone leads.

is the output impedance of my Lafayette HA-350 receiver. I mention this, as the results of the filter will be different with different driving impedances, so this is a point to keep in mind as you use your hamagination in developing your own filter versions.

Figure 4 shows the filter action for two different sets of headphone leads. Naturally since its mission in life is to drive headphones in my own shack, I checked its performance with its intended load. The chart gives the 10 dB down points. The filter looks broader with the magnetic earphones as a load but for all practical purposes, when evaluated by ear, the difference is masked by the difference in performance between the two types of headsets.

You will notice that the filter attenuation curve is not symmetrical about the peak or center frequency. With such a simple filter, it is not practical to achieve symmetry and the effort to do so would be questionable. If you checked the curve past the 10 dB points, you would find that the attenuation on the low side of the center frequency is considerably sharper than on the high side, which gives sort of an inbuilt single signal effect which adds to the effectiveness of the unit.

If is a simple matter to move the center frequency of the filter several hundred cycles by changing the value of the condenser in the shunt resonant circuit leg.

If you don't want to prowl the surplus lanes you can still try rolling your own using the secondary of a plate-to-push-pull-grid transformer in place of the surplus goodie. Many ham shacks have a spare 88 mH toroid floating around and this could be a starting point for the shunt inductor.

. . .W3KBM■

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ELECTRONIC HEALTH

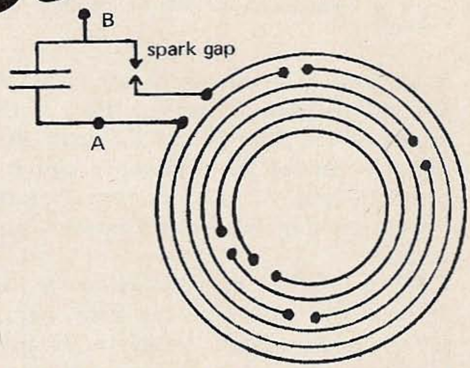

Fig. 1. Tubing may have balls or disks on their ends or strips may overlap for slight fixed condenser effect. Connect the high voltage either to A and B or to A and C. Practically there is no difference.

If there is one thing we readers of 73 have even more in common than our interest in radio I would guess it would be our health in general, though we usually do little about it, and in particular the desire not to die after great pain from cancer. There is something we are qualified to do about it due to our technical knowledge. In fact there is a variety of things we can do about it without resorting to medicines; but a discussion of nutrition, color therapy, reflexology, or Eemans Cooperative Healing or Radiesthesia would be entirely out of place in a radio magazine.

On the other hand, the Lakhovsky Multiwave Oscillator is right down our alley and I feel we might be of genuine service to our fellow man if enough of us made use of this device and it proved of outstanding value. The resulting publicity might then force it to the attention of those needing it most. The Establishment might then be induced to use it.

From many events of the past we may assume or infer that those most qualified to practice a given art or science are also those most reluctant to honestly examine, or test without prejudice, anything new in their respective fields. Torture, ridicule or persecution is often the reward reaped by the innovator.

Due to the stubborn attitude of the orthodox the Lakhovsky Multiwave Oscillator met with acceptance by only a small minority and only while he lived to promote it. Before he died, during WW2, Lakhovsky developed a theory that the individual cells in our bodies contained a nucleus that oscillated at some frequency much as a wire circuit would.

He further reasoned that these oscillations become weak in ill health and could be assisted back to health by artificial stimulation. His first efforts employed the wearing of oscillatory circuits excited by random radiations. These devices were worn as bracelets, belts, anklets, or necklaces. These proved successful but were slow acting. The next step was a powered unit.

Any inductance shunted by capacitance, stray or lumped, will oscillate when externally excited or shocked into oscillation. The belts and bracelets must have therefore been a form of such a basic oscillator circuit. Possibly they were of several conductors of varying lengths with or without more than stray capacity across their open ends.

The Science of Life, by Georges Lakhovsky, gives the theory in detail, but contains no data on construction. The booklet, *Waves that Heal*, by Mark Clement, covers the same ground in less detail. Both have the same pictures of the apparatus and before/after pictures of skin cancer patients. Both have testimonials of several doctors in Italy, France, and England. Larger libraries may have these. I bought my copies from Markham House Press, Ltd., 31 King's Road, London SW 3, England years ago.

The powered unit is essentially a spark transmitter, such as I used aboard merchant ships years ago, tightly coupled to a number of single-turn inductances of progressively smaller diameter from perhaps 20 down to 3–4 in. diameter. The idea is to have as many harmonic frequencies as possible in the powered oscillator and consequently in the auxiliary single-turn oscillating circuits. The conductors or single-turn coils pictured in the books are of copper tubing with little balls on their ends.

One picture shows one turn as the powered oscillator and eleven as auxiliary oscillators. The latter are suspended within the former by silk threads. I mounted mine rigidly by soldering the conductors to screws threaded in ceramic standoff insulators which were mounted on Textolite. I let the ends overlap and used copper strip. There cannot be anything critical about either the number of coils or their dimensions. On shotgun reasoning, the more the better.

Although not essential, another set of auxiliary coils were used by Lakhovsky at a distance of 4–5 ft from the first to slightly increase the overall efficiency. As the object is to have many different frequencies, the reflector coils need not be of the same size as the first nor do they need a condenser and sparkgap.

The treatment consisted of having the affected part of the patient focused between the approximate center of the two coils for about 15 minutes while the power is turned on. Treatments were given once or twice a week. There is no feeling of heat or other sensation and this is definitely not a diathermy apparatus.

As the object is to revitalize cells, the oscillator is not a specific for any particular disease, but I expect it would be most effective near the surface of the body. This is just my opinion. Probably its most spectacular use has been to aid in the rapid elimination in skin cancer in little more than a month and general improvement in skin tissue. I used it to cure a skin cancer as well as to stop a severe toothache and other pains.

One must always bear in mind that any treatment, regardless of its effectiveness, is illegal when used by the layman. The "practice of medicine" without a license may even be stretched to include prayer in some states, so beware. The American Medical Association is not famous for searching for and testing inexpensive remedies for cancer or any other ailments. If you think doctors dare be interested, just ask a few!

The wiring diagram just about explains itself. The sparkgap may be almost any well insulated substantial pieces of metal approximately an eighth of an inch apart. Thin wire would soon burn off. The neon sign transformer I use is rated at 10 kV and 30 mA. The capacitor may be a single unit or combination of series-parallel to total from 0.001 to 0.01 μF at two or more times the voltage rating of the transformer used. One can be made of aluminum foil and plate glass or perhaps you have one left over from your old Tesla coil. Surplus mica capacitors may be bought for a tenth of their original price. Remember that condensers of equal capacities must be used if in series, to obtain equal voltage distribution across them without breakdown. Never increase the length of the sparkgap to see how far the spark will jump as it may ruin the condenser or the high-voltage transformer. Both Meshna and Tab had suitable condensers.

I have absolutely nothing to sell in connection with this project. I like my freedom from jail and disease too. □

Robert M. Brown W9HBF
5611 Middaugh Avenue
Downers Grove IL 60515

EXPERIMENTER'S

One-Tube $10 2-Meter Transceiver

Even in this age of semiconductor sophistication, LSI and varactor tuning, the true dyed-in-the-wool VHF'er sometimes enjoys a little weekend fun working solely from the junkbox. True, the results are not always earth-shattering technological breakthroughs, but they often produce the most-used pieces of equipment in the area.

Such is the history of this embarrassingly simple one-tube 2 meter transceiver. It's withstood the battering of the community's Novices for several years, two field outings and two severe drops to the cement (as evidenced by pronounced dents and an overall appearance not unlike my old '53 Chevrolet). Yet aside from twice replacing the 3A5 tube, it has never required much maintenance.

A look at Fig. 1 reveals the product of at least one man's junkbox (mine). Simplicity is the byword. A carbon microphone was employed simply because it was handy, not necessitating a trip to the local parts supplier. The earphones are the vintage 1–2 kΩ magnetic type, used for the same reason. A multitude of possibilites exist, though, for the reader not desiring to make a straight carbon copy – hence the title of this article. An additional audio stage could easily produce room-filling volume. Conventional crystal oscillators could be worked in to produce rock stability. The tube could be replaced entirely by a VHF transistor. But then it wouldn't be a junkbox project.

In the circuit shown, the right-hand triode section of the 3A5 functions as a 144 MHz oscillator on transmit and as a two-meter superregenerative detector in the "receive" position. The left triode section operates as a headphone audio amplifier during "receive" and as a microphone amplifier/modulator when during "transmit." Switch S1 acts as the manual T/R.

Dc power, as evidenced in the diagram, is such that full battery operation could be supplied for portability if desired. Although rf power input could be appreciably higher if more voltage is applied (up to 80–90V dc), resultant radiation when in the receive position might prove objectionable. A great deal, of course, depends upon the antenna configuration being employed and the degree of 144 MHz population in your area.

Performance

Construction is left pretty much to the builder. As with any VHF project, short to-the-point leads are the vogue. Main tuning is conducted by adjusting the setting of C1. Incidentally, hand capacitance is a factor here – and one that must be reckoned with. For this reason it is advisable to completely house the rig in a small minibox or the like and insure that

of physical switching. So be judicious in where you position your components.

In operation, this is no tropospheric DX hound. Like any superregenerative design, the receiver is extremely sensitive to weak signals but is affected markedly by stronger signals on the band. As a result, operation in a highly congested metropolitan area can be disappointing. Not because you're not being heard, but because your receiver will tend to blanket out.

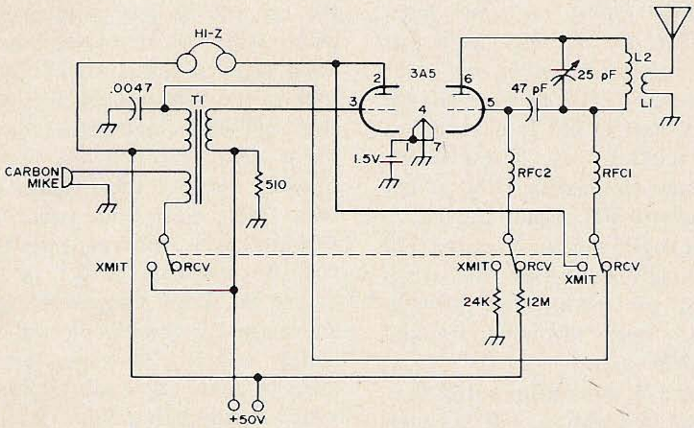

Fig. 1. Circuit diagram of what may be the world's most inexpensive 144 MHz transceiver.

C1 is physically secure. Likewise, L1/L2 are critical and should be mounted to sustain vibration and other environmental considerations without causing a change in operational frequency to take place. Both the variable capacitor and inductors, of course, should be well away from any slight heat that might be generated by the 3A5.

Even if a carbon microphone is employed, it is suggested that this *not* be constructed in conventional hand-held transceiver form. The reason for this is that a wall-mounted mike button forces the user to induce severe vibration both through hand-action and speech – which can affect transmitting frequency. Again, the T/R switch can play a role. You may be listening in one frequency, through the switch, and find yourself transmitting 250 kHz up the band – all caused by the affect

If fed into a highly directional antenna array, however, results can be extremely rewarding. We've had several contacts over distances to 95 miles with this rig, and literally dozens of QSOs within a 40-mile radius. For local work – rabbit hunts, outings, just plain fun, etc – it can't be beat.

Parts List

C1 – 25 pF var.
C2 – 47 pF
C3 – .0047 μF
L1 – 1 turn link of #16 e., ½-in. dia.
L2 – 4-3/4-turns of #16 e., ½-in. dia., ½-in. long
R1 – 510
R2 – 24K
R3 – 12 meg
RFC1,2 – 1.8 μH IRC-CLA
T1 – Triad A-21X
V1 – 3A5

. . . W9HBF■

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Gary, IN 46402

QUESTIONS, QUESTIONS, QUESTIONS?

A friend of mine who operates on 2 meter FM keeps telling me how much better FM is than AM and SSB. He points out that police, fire department, and other commercial mobile VHF services all use FM. Is FM all that good? It depends on what you are looking for. The big advantage of frequency modulation (FM) is that when the received FM signal exceeds a certain critical level, reception on an FM receiver is virtually noise-free. But when the aim is to get the greatest possible communications range through noise and interference, AM has a 4.2 dB (2.5:1) power gain over FM, and SSB is better than either of them. In addition, FM occupies more channel space than either AM or SSB, which is why the FCC limits commercial FM users to frequencies above 30 MHz. On VHF, where there is room for it, however, the noise-free features of FM make it ideal for local network operations.

As long as I am standing still, I get good reception from my mobile installation. But, as soon as I start moving, grinding and popping noises from the loudspeaker cover up the weaker signals. How can I reduce the noise? By law newer cars have more built-in precautions against radio-frequency interference than the older ones did, but to reduce the noise sufficiently for quiet, high-frequency mobile operation often requires more noise suppression than the manufacturer normally furnishes. One or more of the following suggestions may solve your problems. A set of resistor-type spark plugs usually reduces ignition noise appreciably. Make sure that the alternator rings, brushes, and contacts are clean. Tighten all loose connections and bolts in the car and in the transceiver. Bond together with flexible copper strap or copper braid adjacent parts of the body and frame, such as the engine block to the frame, the steering column and metal rods and control shafts going through the firewall to the firewall. Ground the exhaust pipe to the auto frame near both ends of the pipe. Different capacitor companies manufacture coaxial capacitors of 0.1 to 0.25 μF to bypass the input leads of the ignition coil, alternator (or generator), and voltage regulator, and 0.5 μF capacitors for power leads to panel gages, idiot lights, etc., all of which may radiate noise.

Many of the solid-state devices described in various electronics magazines are built on printed-circuit boards. Can I build them without using the printed circuit board? If so, how? Sure. And you can make them look like printed circuit projects (from the top at least) if you wish. Cut a piece of plain perforated board, such

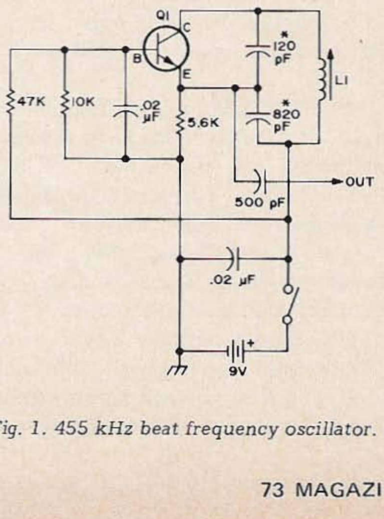


Fig. 1. 455 kHz beat frequency oscillator.

as *Vectorboard* 64AA18, XXXP phenolic, to size with a fine-toothed saw. Mount small components like resistors, capacitors, diodes, and transistors (or transistor sockets) by poking their leads through the holes in the board, and bolt the larger components with screws and bolts. Bolt a small solder lug to each corner of the board and join them together with a square of tinned copper wire around the perimeter of the board for ground connections. Use 20- or 22-gage, tinned copper wire to make the connections between the protruding leads under the board. If the wire is straightened before it is used, it will lay flat against the board without difficulty. After soldering, the extra length can be cut off of the protruding leads. Where connections must cross, insulating tubing may be slid over the leads, or the wire can be threaded through a hole to the top of the board and then returned to the bottom of the board through another hole on the other side of the wire to be crossed.

How powerful a hi-fi amplifier or receiver do I really need for my five-room apartment? Fifteen watts of average sine-wave audio power per channel are usually more than sufficient to fill several interconnected rooms in a home with sound. If the power of the amplifier is rated in the IHF "music power" *watts* however, boost this figure to 25 watts per channel. Actually, how loud a watt of audio power sounds in a given installation depends a great deal on the efficiency of the speakers used and the "hardness" of the room, as well as its size. A room containing heavy, wall-to-wall carpeting and lots of drapes and upholstered furniture will absorb almost three times as much audio signal as a sparsely furnished room with a hard floor and walls. Small "book-case" type hi-fi speakers often sacrifice efficiency to obtain low-distortion reproduction over the full audio-frequency range in spite of their small size. But even under the poorest conditions, 15 watts per channel of sine-wave audio power should produce more than enough sound in a home to satisfy almost anyone, except possibly a deaf "rock music" fan.

Is there anything I can do to my transistor, all-wave radio to receive code on it? The 455 kHz, one-transistor beat-frequency oscillator (bfo) sketched in Fig. 1 should do the trick. All parts, including the battery, will fit comfortably in a 2-3/4 X 2-1/8 X 1-5/8 in. aluminum minibox. Mount the slug-tuned coil and the switch on one end of the box and slip in the rest of the components wherever they fit. A couple of insulated tie strips will support them, and a solder lug or two screwed to the box serve as ground terminals. Almost any reasonably high-frequency NPN silicon transistor besides those listed on the diagram should oscillate in the circuit. Use a length of flexible, insulated wire about a foot long for output coupling. Tune in a station on the receiver, and with the output lead from the bfo draped over the receiver, adjust the slug in the coil to produce a whistle on the received signal. If the receiver is exceptionally stable, you may be able to receive SSB signals on it with the aid of the bfo; the bfo is quite stable.

Can you design me a wide-range antenna coupler for an end-fed antenna? The coupler sketched in Fig. 2 will match almost any single-wire antenna to a receiver or low-power transmitter on almost any frequency, depending upon the inductance of the coil and the position of the coil tap. As a receiver antenna coupler, adjust the capacitor and coil tap for the strongest received signal. As a transmitter coupler, adjust them for minimum swr on an swr bridge between the coupler and the transmitter.

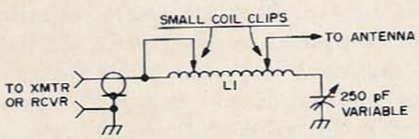


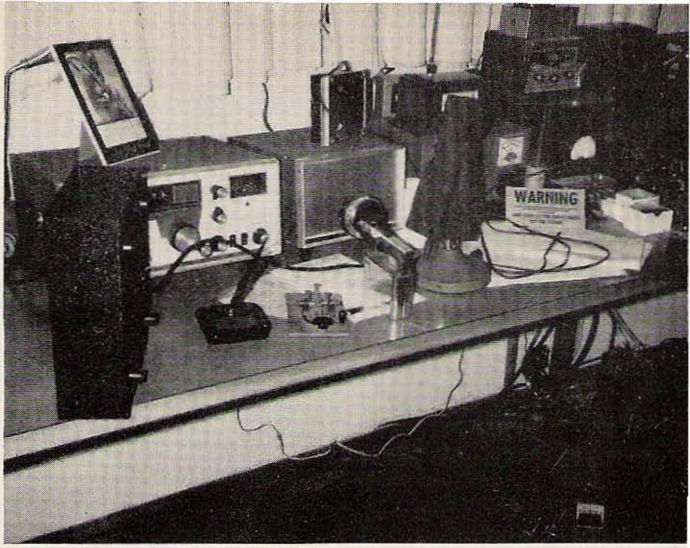
Fig. 2. Wide-range, single-wire antenna coupler for transmitter or receiver.

Mail your questions to: Questions, c/o Herbert S. Brier W9EGQ, Box 678, Gary, IN. 46401.

. . .W9EGQ/KHD 6961■

FOR XYLs and YLs ONLY:

UNDERSTANDING YOUR AMATEUR RADIO OPERATOR



THIS IS A SHACK.
A SHACK IS FOR TINKERING.

Joan Fury,
XYL of Art WA6JLJ

Many articles have been written on how to build amateur radio equipment, how to put an antenna up, how to this and how to that. But few, if any, have been written on understanding the amateur radio operators themselves. So I thought I would undertake this task.

There are many advantages of having a hobby of amateur radio. They are: (1) educational, from the standpoint of gaining technical knowledge regarding radio; (2) social, from the standpoint of family picnics, dinners, or a night out with the boys; and (3) civic minded – just take the case of hurricane Camille and others.

However, with all of the good qualities, there are some idiosyncrasies involved with the world of hamdom which I am sure most wives of hams will recognize as I set them out. Before I start, I realize there are many female ham operators, and to these, I give a hearty "Bravo!" But this article is specifically written for the rest of us females who are really not so inclined as to take up ham radio as a hobby.

Having been married to an amateur radio operator for about eight years, I feel qualified as something of an "expert" on the subject. I remember how excited my OM was when he installed his first radio in the car and how he wanted me to speak into the microphone to the unseen body at the other end. He was the only one who seemed to hear a voice. All I heard was some type of mumbling and static at the other end. Later, it was explained to me, in much detail, as to how the radio needed to be "tinkered with" and then it was going to be really something. This should have been my first clue – the idea of "tinkering . . . " If your husband is a true ham, as mine seems to be, then you know exactly what I mean. They are forever tinkering with something, working ever so hard to get something right, only to trade it for something that doesn't work quite as well – and so the cycle continues. An interesting thing to note: If this breed of ham does buy a new piece of gear, nine times out of nine he has to modify it.

My OM's shack first began in our card table, along with the entire lower portion of a sliding cabinet in the living room. It has now grown to one bedroom filled with test gear, radios, etc., and one entire wall of the garage. But I really don't mind because my OM has "seen the light" in the reasoning of keeping things neat. We have plastic shoe boxes and plastic cabinets filled with things and stuff.

I spoke before of test gear, and I would like to expound on that subject a bit. One day I ventured into the shack and found my OM working on a piece of gear with schematics all around. Upon asking what he was doing, I got the reply that he was building a piece of test gear (let's call the piece of gear "A") so he could test another piece of gear that he was working on (let's call it "B"). It seems that in the middle of building "B", he ran into a snag and had no way of testing it so he had to stop building "B" and start building "A" so he could test "B". At which time, I patted him on the head and left the room before the unknown "C" came into the picture.

A true ham has the instincts of a pack rat. No doubt you know that a pack rat collects shining objects with which to feather his nest. A ham also collects shining objects to feather his shack with, such as transistors, resistors – and the list is endless. A Playboy calendar might also be found in the shack from time to time. And of course, there are the boxes and shelves of transformers which weigh a ton, or seem to.

There is one saving feature: auctions! An auction is an occasion when an item is finally sold, much to the pleasure of the wife, but somehow or other the ham feels he has to come home with some goody, thus continuing the cycle. I remember my first auction; it was held before we were married, and we went to it as a Friday night date. When I heard my husband-to-be was taking me to an auction, I thought how nice and was looking forward to it. (I thought it was going to be a real auction – you know, the kind with antiques, furniture, etc.) Anyway, when we arrived at the auction, I do not think I have to tell you what I saw – anything but antiques as I know them.

I have been tempted to get into ham radio several times, but just as I am getting enthusiastic, "we" get another piece of gear, and somehow my enthusiasm wanes, and I go back to sewing and cooking.

By no means do I mean to belittle the amateur radio world. As I said at the outset, it is a worthwhile hobby. But to the YLs and the XYLs of amateur radio operators, I just wanted to say that I am with you and please treat your amateur radio operator kindly and realize that his little idiosyncrasies are not his alone.

Even if you don't aspire to become a dyed-in-the-silk ham-type XYL, you can become a "quasi" ham by assimilation. You do this by learning his language. Here are a few of the trickier terms:

Hamshack: Not to be confused with the tool shack. The hamshack is usually resplendent with radio gear, most of which is in various stages of modification or repair.

Gear: Not to be confused with a gear in a car or watch. Gear in this case means anything having to do with radio equipment, from the tiniest part to the biggest tower.

Ham: Not to be confused with the meat. This is of the two-legged variety and should be given encouragement if he looks puzzled.

Auction: When this word is mentioned by a ham, it means an auction where absolutely worthless radio gear is sold.

OM: Name given to a male type person who is involved with amateur radio.

XYL - YL: Name given to a female type person who is either married or not married to an OM.

Modify: Usually means, according to Webster's: "To change *somewhat* the form or qualities of." However, in ham language, it means to change beyond all recognition.

Tinkering: The beginning stages of modification.

Static: Secret code that only a true ham can communicate with.

Goody: Something usually without worth, bought at an auction.

Fury■

HIGH POWER SURPLUS FOR 2M FM

by Ken Sessions K6MVH

The days of the surplus buy aren't over yet. In the March and April issues of 73 Magazine, Newsome Electronics* advertised a military surplus rf power amplifier made by Motorola: a rated quarter kilowatt for $350, brand new. There were so many attractive features – not the least of which was the fact that a full modulated FM signal could drive the unit to full output – that I promptly sent off to Newsome an order for one of the power amplifiers. It came about 10 days later.

As shown in the photograph, the unit is very military looking, but exceptionally clean, both in general design and overall appearance. Despite the trunk-like case, the amplifier set consists of nothing more than a control panel and the two basic commodities of all such amplifiers: a husky and conservatively rated power supply and the power amplifier itself.

The power supply, which bears the military designation PP-638/U, is shown schematically in Fig. 1. It is a full-wave, choke-input power source that provides 1000V under full load (250–300 mA). Adding a 4 μF capacitor at the input of the power supply filter choke will increase the output voltage by some 400V. You can actually get almost any kind of voltage you want out of the power supply if you feel like making the necessary modifications. Throwing out the rectifier tubes and replacing them with silicon diodes will contribute to increasing the voltage – and of course you can use a bridge rectifier circuit in place of the full wave. If you do go the whole route, you'll have to make other changes, too – like replacing the final tubes with 4X250Bs, for example. I had a couple of the 250Bs, but I couldn't see going to all that trouble for a couple of dB. I just put a 4 μF capacitor at the filter input and stopped there.

You can't even do what I did without compensating the circuit for the change you made. The unit is overvoltage protected, and a key relay won't trigger if

*Newsome Electronics, 19675 Allen Rd., Trenton MI 48183

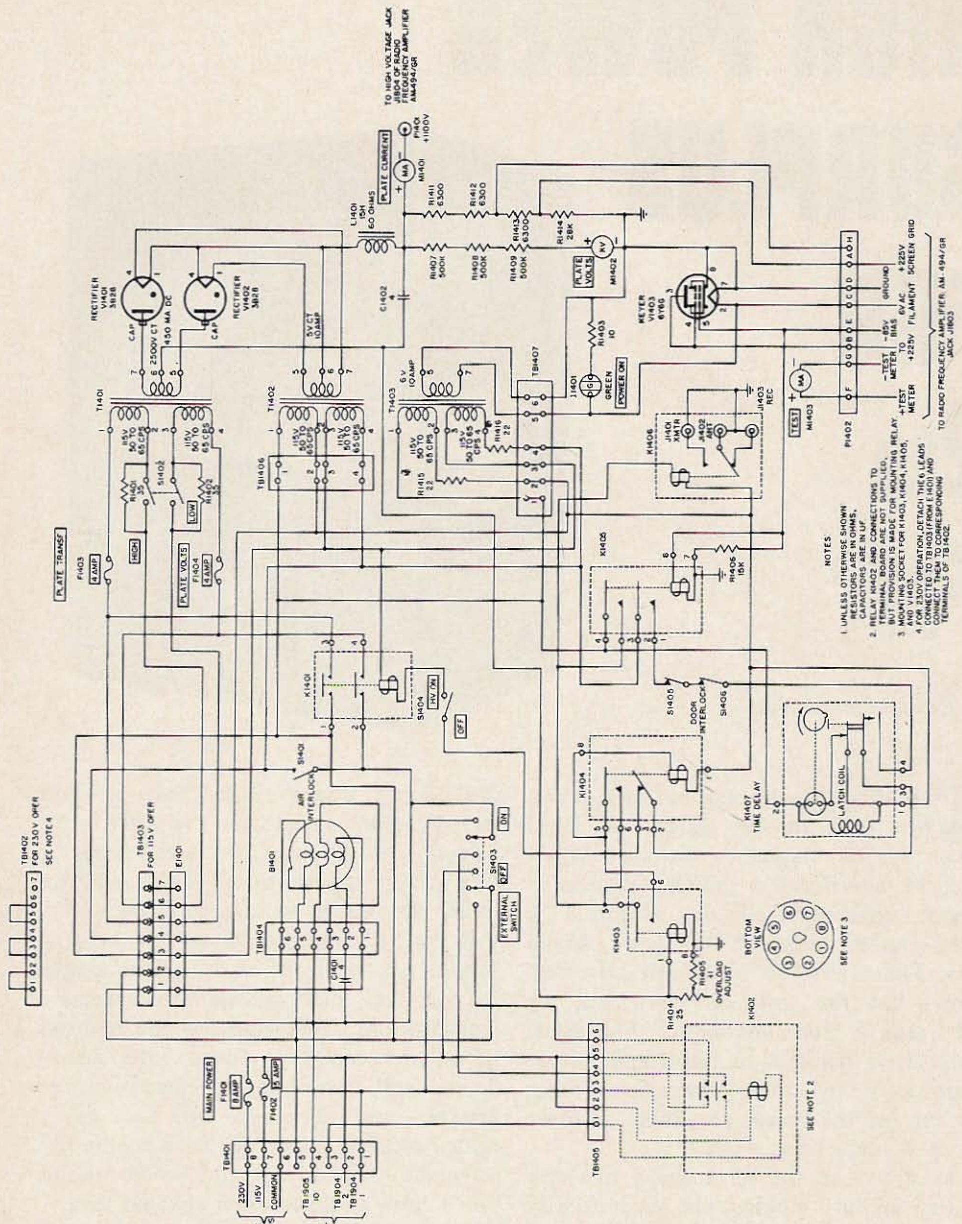


Fig. 1. Power supply schematic.

the voltage exceeds 1100V at a specific point. To change the setting of the overvoltage protection circuit, all you need to do is turn a pot (R1404) on the rear of the cabinet. Full clockwise rotation of the pot defeats the function of the circuit.

Like nearly all pieces of military gear, this rf amplifier has more circuits built for idiot-proofing than it has for performance of its intended function. Several other amateurs in this area sent for the Newsome amplifiers, and a few had trouble getting high voltage. Well, so did I

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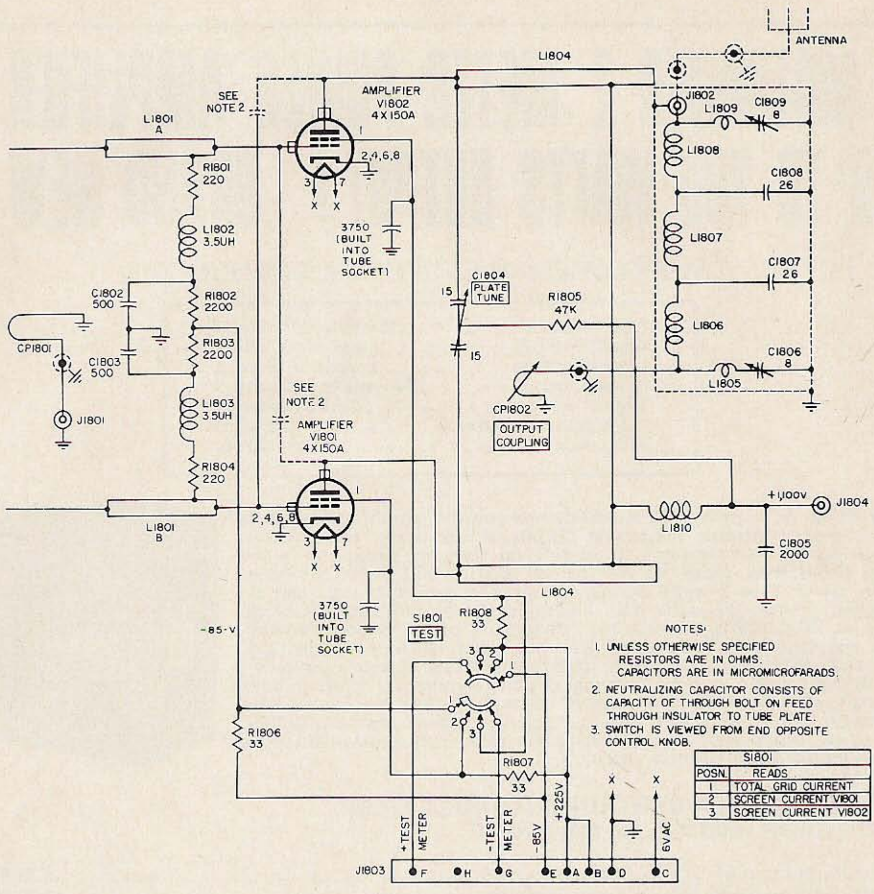

Fig. 2. Radio frequency amplifier, schematic.

until I started looking through the manual. If the drive level on the grid of the final amplifiers drops below 10 mA, the keying relays won't pull in. The relays, once keyed, will stay energized, though, even if the drive falls to around 5 mA. But if you drop power on the input, you won't get the rf amplifier going again until you can generate 10 mA of drive. It seems to require about 8W of transceiver power to get 10 mA of grid drive.

A power supply overload control also disables the plate and screen supply to the amplifier when the plate current reaches an excessive value (420 mA). While this does provide protection against momentary overloads, it does amount to a pain in the neck when you're trying to get the thing tuned up. Your best bet is to use the tune position of the set to get everything in resonance, then switch over to high power. When you do this, it will take only a bit of tweaking to redip.

Figure 2 shows the schematic diagram of the amplifier portion of the system (AM-494/GR). The unit comes equipped with a pair of 4CX150A tetrodes, the same lineup Johnson used in its Thunderbolt kilowatt unit. These are extremely rugged tubes and are capable of comfortably running a full thousand watts input by themselves. The big secret is keeping the bottles cool – which is no problem with this amplifier because an efficient air-blowing system is built right in. Construction of the tube sockets is such that the cooling air circulates from the tube bases up past the ceramic envelopes to the metal cooling-fin structure of the tubes.

The capacitors shown by broken lines in Fig. 2 consist of the inherent capacitance from the tube plates to the bolt and nut on a feedthrough insulator; these small capacitance values serve to partially neutralize the grid-to-plate capacitance of the tubes. Since there is nothing critical about the value of the capacitance, adjustment should not be required. If for some reason it becomes necessary to change the neutralization capacitance, washers of various diameters could be used; but the process would not be fun at all, and the hit-and-miss aspects of it should go a long way toward dissuading prospective tinkerers.

To get the amplifier going, connect a clean rf signal of 8–20W into the input (CW or FM only – this is NOT a linear amplifier). Turn the power switch of the amplifier on, but do not apply plate voltage. Put the TEST switch in the GRID position, and adjust the GRID TUNE control on the amplifier until the TEST meter indicates at least 10 mA of drive. If you can't get an indication of 10 mA, forget about switching on the high voltage; if you do get at least 10 mA of drive, put the PLATE VOLTS switch on the amplifier in the LOW position and switch on the high voltage. From here on, the tuning is exactly the same as your own transmitter: peak the coupling, dip the plate as long as you have a nice smooth swing on the PLATE CURRENT meter. If the dip looks a little sluggish, back off on the coupling and dip at a lower setting on the meter. That's all there is to it.

With a capacitor input supply, the final should dip at around 300 mA. If you are running 1.6 kV, this is a power input of 480W. Assuming an efficiency of around 70%, which is reasonable with class C amplifiers, your power output should be a little more than 325W. And if you've opted to replace the rectifiers with solid-state diodes, you'll get a signal out that will guarantee you at least a watt out for every dollar you've invested. . . .K6MVH■

Evaluation of Swan's 2 & 6 meter Antennas

Paul Schuett WA6CPP
14472 Davis Road
Lodi CA 95240

When I decided to operate on the VHF bands, my first consideration was the antenna system – I made plans for this important feature even before making plans for the rig that I use.

One day I heard about a firm in Stockton, California, that made antennas to order – that led me to Oliver Swan's place of business to discuss 6 and 2 meter antennas.

Having worked in the broadcasting business for some years and having met countless lids who try to convince you that they know a lot more than they really do, it was a real pleasure to converse with Mr. Swan for an hour or so about antenna theory. I learned more in that hour than I had ever learned before on the subject. I can honestly say that there are few people who know as much about antennas as does Oliver Swan.

It was agreed that the Swan Antenna Company would construct and install a two-bay array on 50 and 144 MHz for me. At this time I was just in the process of receiving my amateur license and knew few of the local hams. Had I checked around, I could have saved myself some trouble later, as you will see.

In a few weeks, Mr. Swan's crew arrived and installed the antenna system. Since I was awaiting the arrival of the postman with an envelope from Gettysburg, I did not immediately test the installation, but it was an impressive array. The bays were mounted vertically on a nicely welded boom, which was in turn installed in a heavy duty rotor.

At the same time my income tax refund came, so I blew it on a Swan 250-C (no relation, I understand) to get started on 6 meters. When I connected it and applied power, the swr measured about 3:1.

I was advised that the swr on these beams would be well below 1.5:1; so I contacted Mr. Swan immediately. Nobody in his office appeared to be too concerned with the problem – he gave me some suggestions and that was about it.

After about six weeks of operating into a high swr and getting reports of 5–3 from Sacramento, 40 miles away, WB6JJG and I took down the system so that it could be changed to horizontal polarization. While the antenna was on the ground, I decided to check out the reason for the high swr. Securing a 10-ft piece of conduit, I mounted one of the bays on this. Nothing. Nothing in, nothing out. The other bay worked fine. Checking further, the inside of the balun box appeared as if there had been arcing, although the capacitor checked out okay. An ohmmeter check showed an open connection in the feedline to that bay caused by improperly connecting the BNC connector in the wiring harness.

After solving that problem by fixing the connection, I adjusted the coils in the baluns on each bay by tweaking them closer or farther for minimum swr. I was able to get the swr to 1.2:1 with the antennas supported on a fence post, and at the same time, the signal reports came up.

Now these antennas have been up for a year. We have had a considerable amount of rain and wind in the past few months with more expected before summer. The antennas are not quite horizontal now; they're about five degrees askew with a few loose elements and one or two bent directors.

The materials used in constructing the Swan antennas is top drawer – seamless aluminum tubing and other heavy duty hardware. The bolts and clamps could be designed for a little more rugged duty, as evidenced by an early bad experience with the wind and the weather. I was surprised that the high swr was not detected at the factory if a routine test of the antenna were made. Most users of the antennas will install them themselves; I thought the installation work left something to be desired, as evidenced by the rotor rotating on the shaft and the guy wires breaking.

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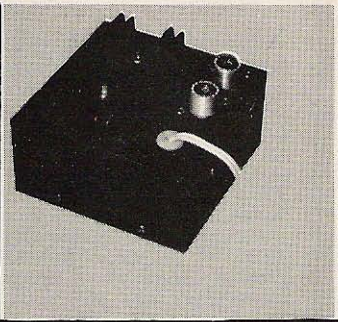

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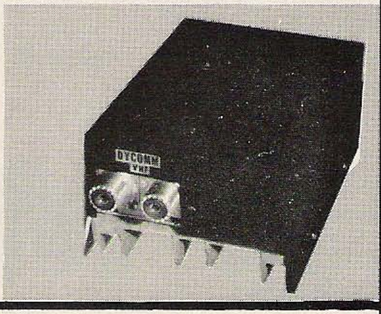

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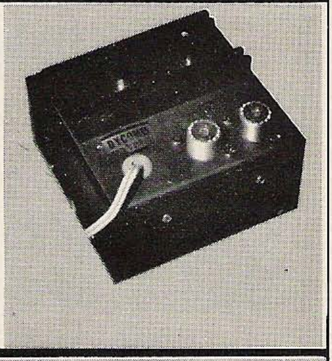

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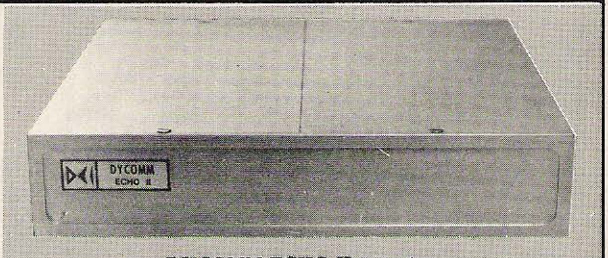

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STUDY GUIDE GENERAL CLASS LICENSE

Part VIII Spread The Word

The usual reason anyone wants a ham ticket is so that he (or she) can legally operate a radio transmitter. After all, no license is required to run a receiver, as dozens of shortwave listeners can testify – but they're missing much of the fun!

Since this *is* the normal reason, it's only natural to expect that the FCC examinations for all grades of amateur licenses would include several questions dealing with the theory and operation of transmitters. The expectation is correct, and the General exam is no exception.

So this month we're going to take up six of the questions from the FCC study list which deal with transmitters. The specific questions at hand are:

6. How does frequency tolerance affect band-edge operation?

17. What is a crystal resonator?

25. Describe briefly how oscillators operate. What are the most common types of oscillators and how do they differ from each other?

29. What is the maximum legal dc power that can be delivered to the final amplifier of an amateur transmitter? How is this power determined?

32. What is neutralization and how does it contribute to proper amplifier operation? What procedure should be followed to properly neutralize an rf amplifier?

50. How can the power input to the final amplifier of an SSB transmitter be determined?

As usual, we won't attempt direct specific answers to these highly specific questions. Instead, we'll rephrase the questions to cover more ground and thus examine the whole area in some depth. This procedure, hopefully, will give you a better chance of passing the exam in case they switch slightly and use different questions which cover similar material.

For starters, we can ask, "What makes up a transmitter?" This will get us off the ground, putting some of the bits and pieces of knowledge we've picked up in the preceding chapters of this study course into something resembling an actual operating gadget. In looking at this question, we'll discover that a transmitter includes, among other things, an oscillator and an amplifier. Logical follow-on questions, then, are, "How does the oscillator operate?" and, "What's unusual about the amplifier?" By the time we've explored these two questions, we'll be fairly solid on the theory end of transmitters, but there's still something to learn about rules, so our final question will be, "Why and how is power measured?"

While our entire emphasis in this installment will be on the applications of the circuits we are examining to transmitters, many of the circuits are also used in receivers, and when we get around to receiver theory we'll be referring back to this section.

Sound like enough for this time around? Let's get at it, then.

What Makes up a Transmitter?

In the most general sense of the word, a radio transmitter is any device which transmits radio energy. The first transmitters used spark gaps to generate this engery, and Marconi spanned the Atlantic with the output of a spark gap transmitter. We've still got some of them around, too, although they're not legal for deliberate use as transmitters (and haven't been for nearly 50 years) – we call them automobiles, and their rf output we call "ignition noise."

However, when we speak of a radio transmitter these days we mean a collection of circuits and apparatus which is used to generate and transmit radio energy – hopefully in accordance with federal and international rules and regulations. Almost all transmitters in action today have five major functional portions,although they may differ in most of their details.

These five major parts of any modern radio transmitter are an oscillator, an amplifier, a power supply, control circuits, and a modulator.

The oscillator controls the radio frequency upon which the transmitter operates, by generating rf energy at some specific frequency. The amplifier boosts the power level of the oscillator's output up to the desired level to be fed to the antenna, and in many cases changes the frequency in some specified manner while doing so. The power supply furnishes operating power to the rest of the components. The control circuits permit the transmitter to be turned on and off, and otherwise to be controlled during operation. The modulator permits the transmitter to carry information; it's a subject unto itself, and we'll look at it next time around.

Figure 1 shows these major components of the typical transmitter in block-diagram form. A small portable transmitter such as those found in hand-held portable (Part 15) transceivers may have only one transistor in the oscillator, another in the amplifier, use a 9V battery as the power supply, have only an on-off switch for control, and use the receiver audio section as a modulator, but all five of the major functions are there. Similarly, a 50 kW broadcast transmitter may use three or four tubes in its oscillator, a dozen or more in the amplifier, have a power supply which takes up the best part of a good-

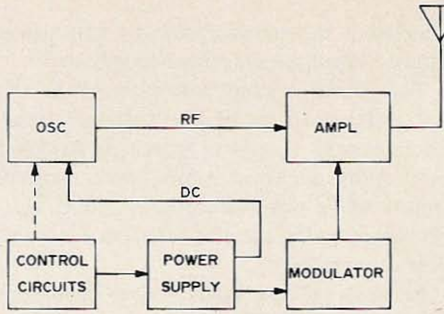

Fig. 1. Every radio transmitter contains these five basic functions, as explained in text. Even a CW transmitter has a modulator.

sized room, make use of elaborate control circuits, and have a modulator bigger than most entire ham rigs. Still, only the five major functions are present.

Since the five major functions are present in all transmitters, from the smallest to the largest, and since no transmitter includes circuits *not* represented by the five major functions, it follows that if we clearly understand the workings of these five functions we must have a clear knowledge of transmitter theory.

We have already examined power supplies in general, and there's not much to add that's unique to the power supplies used in transmitters.

In general, transmitters require larger power supplies than do receivers, because a receiver needs to produce only a few watts of audio power as output (less than that if headphones are used) while transmitters must produce up to several hundred watts of rf output power. Since no transmitter is 100% efficient, production of a 700W output signal (about the best that can be achieved within the ham power limit) requires around 2 kW of dc from the power supplies. The exact ratio between rf output power and dc input power depends largely upon the type of modulation used and is not really important at this stage anyway. The key and pack much more wallop.

In fact, one of the leading ham radio experimenters of all time (Ross Hull, the discoverer of VHF tropospheric propagation) met an untimely death from a transmitter power supply which he was using to power a homebrew TV receiver (in 1934).

Something shorted out and the full power supply output got into his headphones.

The moral is that safety must be the first watchword in all dealings with transmitter power supplies. Interlock switches to prevent access to the power supply circuits while power is on are a good idea, and so are hefty bleeder resistors across all filter capacitors.

Because of the high power levels involved, most transmitter power supplies make use of choke-input filtering, together with full-wave rectification. Mercury-vapor rectifiers are often used in preference to high-vacuum tubes, but high-voltage silicon power diodes are now replacing them. All these steps are taken to reduce power losses in the power supply itself. Yet, even with the most efficient practical power supply circuits, getting 2 kW of dc for the rest of the transmitter often requires the expenditure of 3 to 4 kW of ac from the power line.

The control circuits of a transmitter usually tie in rather closely with the power supply, since they include the off-on switches as well as other operating controls. These circuits differ greatly from transmitter to transmitter, and are often custom designed for each station installation.

One feature frequently found in a transmitter's control circuits is the provision of time-delay relays which delay application of high voltage to the transmitter until after grid bias voltages are applied, and hold back the grid bias until the filaments have warmed up. This greatly reduces stress on the tubes of the transmitter.

On-off switching for the transmitter is usually accomplished by controlling plate voltage to the amplifier. This permits instant changeover from receiving to transmitting, since filament and bias voltages are left on at all times while the station is in use. The same control usually handles antenna switching from receiver to transmitter as well, to permit single-switch operation of the station.

Since the control circuits do vary so greatly from station to station, and are normally just simple power switches in essence (even though they may be hooked together in complicated ways), the license exams do not cover control circuitry – and we'll drop it too.

The modulator is the essential part of the transmitter so far as communication is concerned, but it's a separate subject and will be our target in the next chapter. Its purpose is to put any information to be transmitted by the station onto the "carrier wave" generated by the transmitter, but this can be done in a multitude of ways. Since we'll be looking at this area in detail later, we'll skip it for now.

Which leaves us with only the oscillator and the amplifier to view in the remainder of this chapter.

The purpose of the oscillator is to establish a single specific frequency upon which the transmitter will operate. It accomplishes this purpose by generating an rf signal at this specific frequency, or some other frequency related to it. Output of the oscillator is at very low power level, because any attempt to get high power from an oscillator results in less stable frequency control, and the whole purpose of the oscillator is to provide stable control of the transmitter's frequency. As Robert Heinlein delcared in one of his better science-fiction novels, "there ain't no free lunch." We want stability rather than power from the oscillator, and so we must accept low power output as the price of the meal.

However, the transmitter itself must provide power, and so the amplifier comes into the picture. The amplifier takes the minute output of the oscillator, and brings it up to the power level we desire. Rules say that we must never use more power than that "necessary to maintain communications" – but the judgment of what constitutes "necessary" power is left to the operator, and somehow it always seems to work out that "necessary" means "as much power as you can afford." This leads to the rather ridiculous situation of using a 1 kW station to talk across town, while 1W transmitters are capable of covering the globe, but that's one of our freedoms as hams.

Since the purpose of the amplifier is merely to boost the power of the oscillator's output, the amplifier must not introduce new frequencies of its own into the signal. This requirement leads to certain complications in the amplifier portion of a radio transmitter which are not found in amplifiers for more general uses.

How Does The Oscillator Operate?

We've said several times here that the oscillator "establishes" a single specific operating frequency for the transmitter by generating an rf signal. Some time back, though, we discovered that all electrical energy with which we deal in ham radio comes either from the chemical energy in a battery or the physical motion involved in an alternator or generator, and an oscillator has neither of these. How, then, can it "generate" a signal?

What really happens is that the oscillator *converts* dc energy from its power supply into rf energy at some specific frequency. Far from actually generating anything, the oscillator dissipates a large part of its input power as heat – but the rest is converted from dc into rf.

To see how this happens, we'll have to back up a bit and think about amplifiers. You'll recall from our previous installment that the purpose of any amplifier is to boost the power of its input signal to a higher level.

In a normal amplifier, we feed the input signal in from somewhere else, and do as we will with the higher-powered output signal.

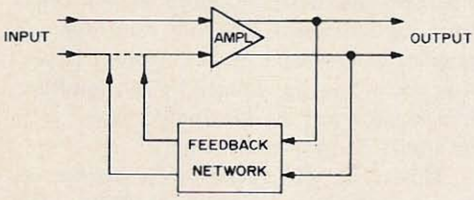

Fig. 2. When a part of the output of an amplifier is fed back to the input, effective characteristics of the amplifier are greatly changed. Normally, only a small fraction of the total output is fed back; function of feedback network is to cut total output down to desired "feedback fraction" for feeding back, and to determine phase of feedback signal with respect to that of input signal.

But what would happen if we took a little of that output signal and fed it back in as an input, as shown in Fig. 2?

Many things might happen. For instance, if the phase relation between input and output is exactly reversed, so that the output signal reaches its positive peak at exactly the same time that the input signal hits negative peak, and if the feedback signal is a small enough fraction of the total output, the amplifier's gain will be reduced, its frequency coverage increased and distortion reduced. This is called "degeneration" or "negative feedback," and is widely used in hi-fi circuits to minimize distortion of all types.

The cathode follower and grounded-grid amplifier circuits are both examples of negative feedback in action.

If the feedback fraction is larger, the apparent behavior of the amplifier will be greatly altered. The differences between cathode followers, grounded-grid circuits, and conventional amplifiers are due entirely to the presence of feedback in large quantities.

On the other hand, if the phase relation between input and output is *not* reversed, but is instead kept in phase so that both input and output signals reach positive peaks together, the picture changes.

With a small feedback fraction, the amplifier's gain is increased, frequency coverage becomes narrower, and distortion rises. This comes about because any small change in input signal will cause a corresponding larger change in output signal, and a part of this change in output signal comes back as additional input to reinforce the original change and make it appear larger. Any distortion introduced by the amplifier is also returned to the input, where it is reamplified — and redistorted.

This type of operation is known as "regeneration" or "positive feedback." It's the basis for the regenerative receiver (which produces rather outstanding performance from a single tube or transistor) and also for the Q-multiplier.

The effects of feedback, both positive and negative, are wrapped up in a simple formula. The effective gain of any amplifier which has feedback connected around it is equal to the "open-loop" gain of that same amplifier (the gain without feedback) divided by what's left when you subtract the product of feedback fraction and open-loop gain from 1. If the feedback is negative, the sign of the feedback fraction is also negative, and the "subtraction" becomes addition instead. If the feedback is positive, the sign of the feedback fraction is also positive, and the subtraction remains subtraction.

That is, if we had an amplifier with open-loop gain of 100 and connected negative feedback around it with a feedback fraction of 0.5%, the product of feedback fraction and gain would be –0.005 times 100, or –0.5 (remember that negative feedback takes negative sign). The quantity to divide by would then be 1 – (–0.5), or 1 + 0.5, which comes out to 1.5 Effective gain of the amplifier would be 100/1.5 or 66.67X.

With the same amplifier, and the same feedback fraction, but using positive feedback, the sign of the fraction would change and the quantity to use for division would become 1 – 0.5, or 0.5. Effective gain is then 100/0.5, or 200. The gain has doubled – but so has the distortion.

With positive feedback, as the feedback fraction is increased for any specific amplifier, the frequency range becomes ever narrower and the gain ever higher. Finally a point is reached when the product of feedback fraction and open-loop gain equals 1. Here the bandwidth of the amplifier becomes virtually zero and the gain is effectively infinite.

When this point is reached, the division factor in our formula becomes 1 – 1, or zero, and division by zero is "illegal." However, we can see what is happening by looking at the gain when the product is just a tiny bit smaller than 1. For instance, with open-loop gain of 100 and feedback fraction of 0.999%, the product becomes 0.999, and effective gain rises to 100/0.001 or 100,000. With feedback fraction of 0.999%, the product is 0.9999 and effective gain is one million. With feedback fraction of 0.999999%, the product is 0.999999 and effective gain is 100 million. You can see that as the feedback fraction increases to drive the product closer and closer to 1, the gain keeps rising at an astronomical rate.

At some point during this rapid rise of gain, no input signal need be supplied to the circuit. Gain is great enough that the random noise caused by motion of the individual electrons within the wires and components of the circuit itself is enough to cause maximum output, and as soon as any output appears that provides all the input necessary to keep things going indefinitely. This self-sustaining circuit is what we call an oscillator, because it oscillates from one state to another continually.

The precise point at which oscillation occurs can be predicted by part of the feedback formula. Whenever the product of gain and feedback fraction become equal to 1, oscillation is sure to result. The oscillation prevents the product from ever becoming greater than 1, incidentally.

This implies that any amplifier can be turned into an oscillator by simply providing enough positive feedback around the amplifier, and the implication is absolutely correct. If the amplifier has no tuned circuits, the oscillation frequency will be determined by the time it takes the amplifier's coupling capacitors to charge and discharge. We call this kind of oscillator a "multivibrator," and it finds wide use in TV, computer, and radar circuitry. We won't go into it here because it's not required for the General class ham ticket.

If the amplifier has neither tuned circuits nor coupling capacitors, then the oscillator has a frequency of zero. This might not seem like much of a circuit to have around, but it's known to the computer industry as a "flip-flop" and provides one of the most popular memory circuits around for information processing. Again, since it's not required for the General class exam, we won't go into this more deeply.

The kinds of oscillators we're interested in right now all do have tuned circuits, and are based upon rf amplifiers. The tuned circuits are adjusted to provide maximum gain at some specific frequency, and it's the gain at this frequency (center frequency) which fits into the feedback formula. Thus, when oscillation occurs, the oscillation is at the frequency to which the resonant circuits of the amplifier are tuned.

Because of this, we separate the frequency-determining circuits of an oscillator from the rest of it, and call them the "resonator." Requirements for a single-frequency oscillator are, then, threefold. We must have an amplifier, a resonator, and a feedback network.

The feedback network provides the essential feedback, the resonator provides frequency control, and the amplifier keeps things going. These three components of every single-frequency oscillator are shown in Fig. 3.

The purpose of an oscillator in a radio transmitter is to control that transmitter's frequency, and this means that the frequency of the oscillator must be as stable as possible. This requirement for high frequency stability influences all three parts of the oscillator circuit.

Feedback control is essential, because with too much feedback the gain can be 1 at frequencies which are not exactly at the frequency of maximum gain. This permits the oscillator frequency to wander about, which defeats our purpose. For this reason, no more feedback should ever be used than is required to keep the oscillator going.

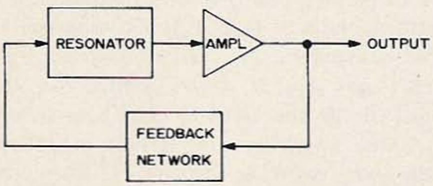

Fig. 3. Addition of resonator to feedback arrangement of Fig. 2, with proper phase of feedback and feedback fraction large enough to elminate any need for external input, produces a tuned oscillator. All rf oscillators in common use share these three components, and the differences between one type of oscillator and another all lie in the manner in which one or more of the three basic functions is achieved.

The resonator, since it determines the frequency in the first place, must be able to stay tuned to one frequency for an extended time period. This is not so simple as it might sound. For instance, the wire of which a coil is wound expands as it heats, and the passage of current through that wire results in heat being applied to the wire. As the wire expands, the coil dimensions change. Even though the change is microscopic, it will still change the coil's inductance and consequently change the frequency to which the circuit is tuned. In practice, this effect may cause a frequency shift of several kilohertz – enough to take a signal right out of a ham band if you're operating near the edge.

When the utmost in frequency stability is required from an oscillator, then, the resonator is hardly ever a simple tuned circuit. Instead, quartz crystals or "crystal resonators" are used. These are thin plates of quartz, ground to precise sizes and thicknesses, which act exactly like tuned circuits to an oscillator circuit but which are far less effected by the circuit's operation than are ordinary coils and capacitors.

Not all frequency-determining crystals are quartz, but the vast majority are. Quartz is one of the most sturdy of many substances which have a property called "piezoelectricity;" this oversized word means simply that these substances produce electricity when squeezed, pressed, bent, or otherwise mechanically deformed, and conversely can be deformed by application of electrical energy. The crystal in a crystal microphone is another piezoelectric substance.

The crystal resonator gets its frequency stability from the fact that it uses *physical* resonance rather than *electrical* resonance, which eliminates one whole level of physical-to-electrical translations from the process.

When an alternating voltage is applied across the proper faces of a crystal resonator, the crystal will vibrate in step with the voltage. If the frequency of the voltage is such that the vibration is "in tune" with the natural vibration frequency of the crystal, the resulting vibrations will be much larger than if it is not.

In other words, the exchange of energy between the electrical and the mechanical states is much more efficient if the electrical frequency matches the mechanical vibration frequency; this means that very little energy is lost in the transition under such conditions.

If we were to suddenly remove the voltage, the crystal would continue to vibrate for at least a little while, like a Chinese gong which has been struck one time. Each vibration would produce electrical energy which could go back into the external circuit. This is exactly like the energy-swapping role of the LC tuned circuit, and is what makes the crystal resonator act (to the oscillator) exactly like a tuned circuit.

Even though the frequency stability of a crystal resonator is normally much greater than that of an LC circuit, some care is still necessary. Many crystals are capable of acting as resonators at several frequencies, and you have to be certain that you're using the frequency you intended to. The crystal itself can be heated by circuit action, and this will change its dimensions and therefore its frequency. And finally, the dimensions of the crystal itself are always subject to manufacturing and processing tolerances, so that the frequency stamped on the case is not ever exact, but itself has a tolerance. This tolerance must be taken into account whenever you're operating near the edge of a band, or any other time when exact frequency control is important.

Crystal frequency tolerances are usually specified in percent, and a typical tolerance is 0.01%. This means that, in the specified oscillator circuit, the crystal's frequency will be within 0.01% of the marked frequency. The higher the frequency of the crystal, the greater the absolute possible error in hertz. For instance, a 0.01% crystal for 14 MHz might have a true frequency anywhere between 13.9986 MHz (14 – (0.0001 x 14)) and 14.0014 MHz. A crystal to the same tolerance for 7 MHz could have true frequency from 6.993 to 7.0007 MHz. In the first case, absolute possible error is 1.4 kHz; in the second, 700 Hz, just half as much.

This tolerance must be kept in mind when ordering band-edge crystals. The lowest frequency to order, with 0.01% tolerance, for operation in the 7 MHz band, would be 7.00071 MHz. With maximum low-side error, this would still come out as 7.00071–0.0070071, or 7.0000099 MHz, less than 10 hertz inside the band limit.

The way to calculate the tolerance is to add the tolerance to 100%, then multiply the band-edge frequency by the result if you're ordering for the low end of the band, or divide the band-edge frequency by the result if you're going for the upper end (either way, your answer will be farther inside the band than the exact limit). Then round off the answer in the direction which takes you still more inside the band.

While we've discussed tolerance mainly in connection with crystal resonators, an LC resonator has tolerances too, and the same kinds of considerations apply. Any time operation is planned near a band edge, it's necessary to be certain that you know exactly where that band edge is, and keep your signal on the legal side of it.

The major advantage of the crystal resonator is its stability, but at the same time this leads to a drawback. The frequency of a crystal resonator is difficult to change. Because of this, variable frequency oscillators (vfo circuits) using LC resonators are highly popular.

Both crystal and variable frequency oscillators operate in essentially the same way; the major technical difference is the type of resonator used, and the major operational difference is that the vfo is less stable but often more convenient to use than is the crystal.

Most of the common oscillator circuits come in both crystal and vfo forms, but sometimes different names are applied to the two versions of the same circuit. Since all oscillators used in radio transmitters must include the three basic components shown in Fig. 3, the major differences between different oscillator circuits are the ways in which these components are interconnected. In most cases, but not all, the variations occur in the connection of the feedback network.

The feedback network must couple output back to input in the proper phase, and with the proper feedback fraction, but so long as it accomplishes these two tasks everything else about it is free to vary without limit. Thus it can be placed at almost any point in an amplifier circuit where it can mesh output with input. Some oscillators (such as the Armstrong and tune-plate-tuned-grid circuits) have it connected to the plate, while others (such as the Hartley and Colpitts arrangements) have it in the cathode circuit.

Figure 4–8 show several oscillator circuits, including those in most common use today. In all these illustrations, the feedback network is indicated by heavy lines.

Figure 4 is the oldest of all oscillator circuits using vacuum tubes, the Armstrong

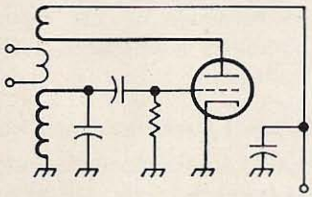

Fig. 4. Armstrong oscillator; feedback is via a "tickler" coil.

oscillator. It works only with an LC resonator, which is in the grid circuit, and the feedback is applied by means of a coil in the plate circuit which is coupled to the grid coil. This plate coil is called the "tickler" and its number of turns is adjusted to vary the feedback fraction.

The Armstrong oscillator is virtually obsolete today, although it's still around in some regenerative detector circuits and sometimes finds use in receiver local oscillators. We include it both for its historical interest and because it spotlights so clearly the feedback function of all oscillators.

Figure 5 is the "tuned-plate-tuned-grid"

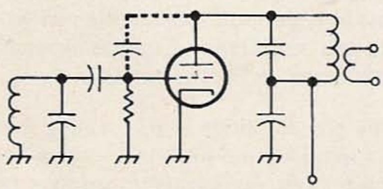

Fig. 5. Tune-plate tuned-grid oscillator feedback path runs through the grid-plate capacitance of tube.

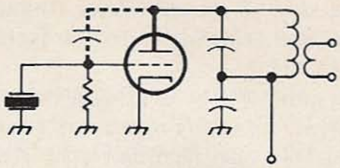

Fig. 6. Miller crystal oscillator is simply a crystal version of TPTG circuit (Fig. 5), with a crystal replacing the grid tank circuit.

(TPTG) oscillator. This circuit is identical to a triode amplifier circuit which has not been neutralized, and oscillates when the plate and grid circuits are tuned to slightly different frequencies. The feedback path in this one is through the tube, by means of plate-to-grid capacitance. While the TPTG oscillator is also obsolete, its basic principle survives in the circuit of Fig. 6.

This circuit, the Miller crystal oscillator, simply substitutes a crystal resonator for the TPTG's tuned-grid circuit. The resulting oscillator is widely used in VHF transmitters. As in the TPTG, feedback is through the tube, and plate-circuit tuning is critical. For best results, the plate must be tuned to a frequency slightly different from the crystal.

The Hartley oscillator (Fig. 7) can readily be recognized by its tapped grid coil and the fact that the cathode returns to the

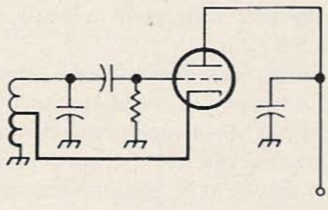

Fig. 7. The Hartley oscillator is always identified by a cathode tap on the coil.

coil tap rather than to ground. Feedback is via the cathode circuit, and is adjusted by varying the tap position (normally by adding or removing turns at the grid end of the coil, which effectively moves the tap down or up the total coil). This circuit is almost universally used for receiver local oscillators, and is also found in transmitters both as a vfo and in a crystal version. In the crystal version, the crystal does not replace the LC tuned circuit. Instead, it replaces the coupling capacitor from grid to tuned circuit.

The most widely used oscillator circuit at present, however, is the one shown in Fig. 8. This one, identifiable by the two series-connected capacitors from grid to ground and the cathode connection to the junction of these capacitors, goes under at least three different names, which identify the variations shown as A, B, and C in the illustration.

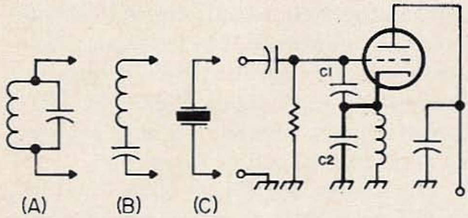

Fig. 8. Capacitance feedback circuit goes under various names, depending on the tuned-circuit arrangement.

All three versions obtain their feedback from the cathode circuit, by voltage-divider action in the series capacitors. The circuit is electrically equivalent to the tapped coil of the Hartley oscillator, but in practice is easier to adjust because either or both of the capacitors may be an adjustable trimmer, permitting convenient adjustment of feedback fraction.

The differences between the three versions all involve the resonator portion of the circuit. When a high-capacitance, low-inductance LC resonator is used and connected as shown at A, the circuit is called a "high-C Colpitts" oscillator. This version is popular as a vfo. It can be designed to permit extremely precise tuning and high stability.

When a low-capacitance, high-inductance LC resonator is connected as shown at B, the result is the *Clapp* oscillator. At one time this circuit was almost exclusively used for vfo's, but in recent years its sensitivity to small changes of capacitance has caused it to decline somewhat in popularity. It's still around in goodly numbers, though.

When a crystal resonator is used as at C, the circuit is called both a "grid-plate" oscillator and a "crystal Colpitts" circuit. Quite possibly more crystal oscillator circuits in use today are of the Colpitts variety than are of any other single type. Since no tuning coil is necessary, the circuit covers a wide frequency range; all that's necessary is to plug in a crystal for the frequency desired. Addition of a tuning coil in the plate circuit makes it easy to pick off any desired multiple of the crystal frequency – a popular feature with VHF operators who often use this circuit with an 8 MHz crystal to get 24 or 25 MHz output direct from the oscillator by taking the third harmonic of the crystal frequency. Stability is excellent, and power output is adequate.

What's Unusual About the Amplifier?

We've already examined the subject of amplifiers in general several times so far in this study course, but the amplifier of a transmitter is a bit different from the common run of amplifier circuit. Our question, then, is "how?"

In a transmitter, the amplifier portion serves several purposes. Most obvious is its action in stepping up the relatively feeble output of the oscillator to the power level desired for feeding to the antenna. Not so obvious is its action of "isolating" the oscillator from external influences.

The oscillator, you see, is a rather sensitive circuit. Almost anything – a change in operating voltage, variations in the applied load, or mechanical vibration – can cause its frequency to change. This is something which we do not wish to have happen, and so we connect an amplifier between the oscillator and the antenna even when the oscillator is capable of delivering enough power by itself, in order to provide a constant load on the oscillator and let the variations of operating conditions all be applied to the amplifier.

While the amplifier is performing both these functions, it must of course not introduce any unwanted output frequencies of its own, nor must it influence the oscillator's frequency, itself.

The result of these requirements is that the portion of a radio transmitter which we are here calling "the amplifier" normally is not just a single amplifier stage, but instead is a whole string of amplifiers connected end to end. Some are designed to provide isolation, and some for power handling.

The last stage in the amplifier (the one which feeds the antenna) is called the "final" for reasons which should be apparent. Between the oscillator and the final, we may encounter "buffer" stages which are intended primarily to provide oscillator isolation, "driver" stages which are intended to boost power level up to that required by the final as its input, or both.

The buffer stages accomplish their function of providing isolation in several ways. To begin with, every amplifier stage, whether intended as a buffer or not, provides at least some isolation between the stage which precedes it and the stage which follows. Some buffers, then, are indistinguishable from any other rf power amplifier designs.

Occasionally a circuit designer will set up a buffer stage to operate in class A rather than in class C (the normal operating condition for rf power amplifiers). This is done because a properly operating class A amplifier imposes no load on the stage which precedes it, yet is capable of providing sufficient power output to drive a class C stage behind it. If a class A buffer is used, it normally is driven by the oscillator itself; with no (or little) loading upon the amplifier, frequency stability is increased.

Another trick sometimes used in buffer design is to employ a cathode follower rather than a normal grounded-cathode circuit. The cathode follower, with its 100% negative feedback, is noted for its isolation-providing capability. While it cannot produce any voltage gain, it can and does provide power amplification.

One of the most popular techniques used in buffering, though, is to operate the oscillator at some submultiple of the desired output frequency, and then use a frequency-multiplying stage or stages as the buffer.

A frequency multiplier looks just like an ordinary amplifier, but is operated with additional bias (deeper into class C), and its input and output circuits are tuned to different frequencies. The class C operation provides current pulses in the output circuit, and if the output tank is tuned to a frequency twice that of the input, these pulses will occur every other cycle of output frequency. That's often enough to keep things going; multiplication of up to 5 times in one stage is possible.

With the input and output circuits of the multiplier stage operating at different frequencies, isolation between them is naturally better than if they were on the same frequency.

This technique is virtually standard practice with vfo circuits. Most ham vfo's operate in the 1.75 MHz region to provide output at 3.5 and 7.0 MHz, and in the 7 MHz region for output at 14, 21, and 28 MHz. VHF vfo's usually operate in the 8.0 to 8.33 MHz region, providing output at 24 or 25 MHz, which is then multiplied again in the transmitter, by 2 to reach 50 MHz and by 6 to get up to 144 MHz.

Frequency multipliers are also used as drivers, but their efficiency is much less than that of "straight-through" or "straight" amplifiers (those in which input and output are on the same frequency). A multiplier which doubles its input frequency provides about half the output that the same circuit would give in straight through operation; a tripler gives about one third, a quadrupler about one fourth, and so forth.

One great advantage of multiplier stages is that they cannot oscillate because the output signal is different in frequency from the input signal, and so feedback cannot be sustained. A straight through amplifier, on the other hand, is virtually the same circuit as the TPTG oscillator, and if triodes are used it must be neutralized to prevent "self-oscillation." Even with multigrid tubes, which make it possible to operate without neutralization, it's still a good idea to neutralize all straight amplifiers in a transmitter, to keep out of trouble.

Neutralization is the technique of cancelling out all positive feedback from an rf amplifier stage, in order to make it impossible for that stage to oscillate. While the amplifier may have been designed to avoid positive feedback, when the thing is actually built it's almost impossible to get rid of all possible feedback sources. Stray capacitance, power wiring, magnetic coupling between coils, and similar factors bring in feedback whether we want it or not. Careful parts layout can minimize the problem, but cannot eliminate it.

Since we cannot eliminate all the positive feedback, we neutralize it instead. We do this by adding negative feedback to the circuit. The negative feedback cancels out the positive feedback, and the net result is (ideally) no feedback at all. In practice, we usually adjust everything to slightly "over-neutralize" the stage, in order to have a safety factor against component aging and the like, and also because our means of detecting exact neutralization are not completely accurate.

Some of the ills which can be prevented or eliminated by proper neutralization of the amplifier include self-oscillation, erratic shifts of stage gain with small changes in operating frequency, non-linear distortion in modulated amplifiers, and splattering in SSB linear circuits. x Several procedures

Several procedures may be followed to properly neutralize an rf amplifier. All involve balancing out the unwanted positive feedback by artifically supplied (and adjustable) negative feedback, and detecting the balance point by means of a sensitive indicator. The negative feedback is usually taken from the plate circuit to the grid circuit.

Figure 9 shows a typical neutralization circuit, based on recommendations in the ARRL handbook. Capacitor C1 is the normal bypass capacitor for the grid tank, and C2 is the neutralizing capacitor.

Even though we often consider a bypass capacitor to be a "dead short" for rf energy, actually it must always have at least a little impedance at any frequency lower than infinity. C1, therefore, is not ever a true short for rf, and any signals which are applied across C1 must also appear at the grid end of the circuit. C2 is of much smaller capacitance than C1, which means that it has much greater

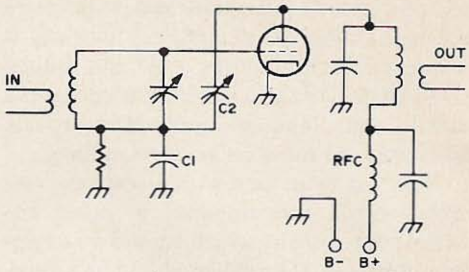

Fig. 9. Neutralization circuit for conventional single-ended rf amplifier makes use of voltage-divider action of capacitors C2 and C1, in series, to provide negative feedback from plate to grid circuit. C1 is normal grid bypass capacitor and C2 is called the neutralizing capacitor. Normally C1's value is fixed and C2 is variable. By adjustment of C2, negative feedback through neutralization circuit is made to balance out any positive feedback from rest of circuit which might cause amplifier to oscillate.

impedance at any frequency, and so the two capacitors together form a voltage divider between the tube's plate and ground. The small part of the plate signal which appears across C2 is thus fed back into the grid circuit, and the capacitance ratio between C1 and C2 determines the feedback fraction. The feedback is made negative, as required, by the fact that plate and grid voltages in a grounded-cathode amplifier are exactly out of phase with each other.

Adjustment is accomplished by varying the value of either C1 or C2, leaving the other's value fixed, until no feedback exists. In most transmitters, C2 is adjusted and C1 is fixed in value. Special "neutralizing capacitors" with very small capacitance and high-voltage insulation are available for this purpose. Alternatively, C2 can be left fixed, and C1's value adjusted. In this case, high capacitance trimmers or variable capacitors are required at C1, but the requirement for high-voltage insulation is minimized.

Whichever of the two is adjusted, the procedures are the same.

One of the most common procedures for neutralization begins with the removal of all supply voltages except filament power from the stage being neutralized. Then a sensitive rf indicator, such as a vacuum-tube voltmeter with rf probe, is coupled to the output side of the stage, and the stage is driven at full rated input (drive) power. Since no power is being supplied to the stage, any rf which appears at the output indicator must be the result of a feedback path.

While driving the stage and observing the output indicator, the neutralization adjustment is then varied slightly. If indicated output increases, the adjustment is moved in the other direction. With careful adjustment, the fed-through power can be reduced to a level too low to be detected by the indicator, and the stage is then considered to be neutralized. When this point is reached, the positive and neative feedback paths are cancelling each other out, and effectively no feedback at all exists within the circuit.

Another procedure for neutralization eliminates the requirement for an output indicator, but applies only to class C stages in which grid current is metered. Drive power is applied in the absence of power-supply voltage, and the input tuning adjusted for maximum indicated grid current. The output tuning is then swung through its range. If a feedback path exists, the grid-current reading will fluctuate as the output tank tunes through resonance, as it absorbs some of the drive energy via the feedback path. The neutralization is then adjusted until this "flicker" of the meter is eliminated.

Either procedure is accurate enough for all practical purposes. The one using an output indicator applies to all kinds of rf amplifiers, while that using the grid-current meter applies only to amplifiers which draw grid current and which have provisions for metering it.

Not all rf amplifiers are "single-ended;" a circuit called "push-pull" is popular for rf amplifier use, and its neutralization is handled in a slightly different manner.

With a push-pull amplifier, the neutralizing capacitors are connected from the plate of one tube to the grid of the other as shown in Fig. 10. Adjustment is similar to that for single-ended stages, with the added complication that the two separate ad-

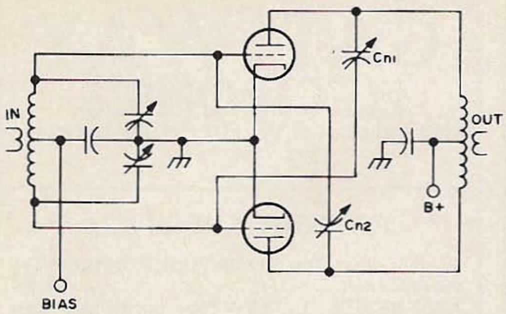

Fig. 10. Neutralization techniques for push-pull amplifiers differ somewhat from that shown in Fig. 9. Here two neutralizing capacitors are used; they connect from plate of one tube to grid of other and vice versa. Since two tubes always operate out of phase with each other, feedback still works out to be negative. The two neutralizing capacitors interact with each other, and adjustment of both must be checked whenever either is adjusted.

justments interact with each other and both must be checked every time.

Why and How is Power Measured?

It's fairly simple to explain *why* the dc power input to an amateur radio transmitter must be measured. Section 97.67 of the FCC Rules and Regulations declares that "except for power restrictions as set forth in 97.61, each amateur transmitter may be operated with a power input not exceeding 1 kilowatt to the plate circuit . . . " The restrictions referred to limit power input in the 160-meter (1.8 MHz) band on a state-by-state basis to prevent interference with the LORAN navigation system, and in the 420–450 MHz band on a regional basis to prevent interference with space telemetry and military experimental radar installation.

Additionally, transmitters operated by Novices are limited to a maximum power input of 75W. In general, though, the power limit for the most popular ham bands is 1 kW. That's what we mean when we say "the legal limit" or "a full gallon."

And even when the limit is lower, such as the 100W permitted for many states in daytime on the 160 meter band, or the 25 to 200W permitted on 160 at night, we still must measure the power to be certain that we never exceed the legal limit for the specific frequency and the specific time at which we are operating.

While we're on the subject of legal limits, it's well to point out that Section 324 of the Communications Act of 1934 includes another legal limit which supersedes that imposed by FCC rules. It's rather specific, too: "In all circumstances, except in case of radio communications or signals relating to vessels in distress, all radio stations, including those owned and operated by the United States, shall use the *minimum amount of power necessary* to carry out the communication desired." (Emphasis supplied.)

That boils down to this: We can never use more power than FCC rules permit, but we cannot use even that much unless it's necessary to carry out the communications.

Unfortunately for the interests of interference reduction, the judgment of how much is "necessary" appears to be entirely subjective, and we have never heard of any operator getting into trouble for using "more power than necessary" – although several have had their licenses suspended and a number of operating awards have been revoked for using more power than FCC rules permit.

The same section of the FCC rules which sets the 1 kW limit goes on to specify just a little bit about how the measurement is to be made. "An amateur transmitter operating with a power input exceeding 900W to the plate circuit," it says, "shall provide means for accurately measuring the plate power input to the vacuum tube or tubes supplying power to the antenna."

Below the 900W level, apparently, an "educated guess" is adequate measurement. In point of fact, the dc plate power input is determined by multiplying plate supply voltage times plate current. Some method of measuring plate current is necessary in order to properly tune the transmitter, and this is usually a milliammeter. At low to moderate power levels, many operators simply multiply the measured plate current by the calculated plate supply voltage, which is a little better than an "educated guess" but not good enough for high-power use. For 900W or above, it's necessary to have both a voltmeter and a milliammeter on the plate circuit in order to comply with the rule which requires means for accurate measurement. It's also a good idea when operating within 10% of the power limit on any of the bands which have lower power limits.

Now that we know why it's necessary to measure power input, let's see how it is done. We've already indicated the actual technique; measure or estimate the plate voltage, and multiply by the measured plate current. But just how should we measure current?

For ordinary AM phone operation, it might not be too confusing. The plate-current meter of a properly operating phone transmitter remains steady, so you have only one reading to concern yourself with.

But, as we shall see next time out, the actual peak power input to the transmitter is at least half again greater than the indicated dc input, and may be twice as great, depending upon your definition for "peak power input."

Should that concern us in our power measurement? This question has not, so far as we know, been officially answered, but in practice the answer is no. The power input referred to by the FCC is the indicated power input, and the additional power involved in AM phone operation is ac power from the modulator.

How about a controlled-carrier AM rig, in which the indicated plate current gyrates with modulation? Or, worse yet, a single sideband transmitter, which has no input power in the absence of speech, yet fluctuates all over the current dial when modulation is applied?

The answer for both these cases is that the measured power, as indicated on the panel meters, must never exceed the legal limit. The FCC recognizes that instantaneous power peaks may easily go above the limit, but by specifying a quarter-second time constant for the meters they assure that this apparent loophole is not really very big, and put SSB and controlled-carrier operations into the same class as AM (where some of the power, which does not show up on the meters, is "limit-free").

What About FM? The FM operator doesn't get off so well. His power must be measured on a carrier-level basis, just like the AM operator – but he gets no free-power bonus when he adds modulation.

And CW? CW fares poorest of all, because the policy is that power input to a CW transmitter must be measured with the key held firmly down, and this is a condition which is prohibited for any other purpose on the popular CW bands. When CW is being used, the plate current meter fluctuates just as does that of an SSB rig, but the CW operator does not have the freedom to load up to higher power levels and use the "highest flicker" method of reading his power input. He must make his measurement with the key down, and as a result actual measured power during operation seldom exceeds 75% of the "measured" value for official purposes.

To summarize, all transmitter power measurements except those for SSB and controlled-carrier AM are made with the transmitter carrier turned on, but no modulation applied. The plate supply voltage of each tube supplying power to the antenna is measured individually (use care – high voltages are usually present), and the plate current of each tube is similarly measured individually. Legal power input to each stage is the product of that stage's supply voltage times plate current, and the transmitter's power input is the total of the individual power inputs of each stage which provides power to the antenna.

For SSB and controlled-carrier AM, plate voltage and current measurements are performed during normal operation, with modulation applied, and the "highest flicker" of each meter is noted. These "highest flicker" readings are used to determine legal power input to the stage, and as in the other case the power input of the transmitter is the total of all stages feeding the antenna.

. . .Staff■

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EASTERN UNITED STATES TO:

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ALASKA	14	14	14	7A	7	7	7	7	7A	14	14	14
ARGENTINA	21	14	14	14	14	7	14A	21	21	21	21A	21A
AUSTRALIA	21	21	14	14	7B	7B	14	14B	14	7A	14A	21
CANAL ZONE	21	14	14	14	7	7	14	21	21	21	21A	21
ENGLAND	7A	7	7	7	7	14	14	14	14	21	14A	14
HAWAII	21	14	14	7B	7	7	7	7	14	14A	21	21
INDIA	14	7B	7B	7B	7B	7B	14	14	14	14	14	14
JAPAN	14	14	14	7B	7B	7	7	14B	14	14	14	14
MEXICO	21	14	14	14	7A	7	14	14	14A	21	21	21
PHILIPPINES	14	14	7A	7B	7B	7B	7B	14B	14	14	14	14
PUERTO RICO	14	14	14	7	7	7	14	14	14	14A	21	21
SOUTH AFRICA	14	14	7	14	14B	14	21	21	21A	21	21	14A
U. S. S. R.	7	7	7	7	7	14	14	14	14	14	14	7A
WEST COAST	21	14	14	7	7	7	14	14	14	21	21	21

CENTRAL UNITED STATES TO:

ALASKA	14	14	14	7A	7	7	7	7	14	14	14	14
ARGENTINA	21	21	14	14	14	14	14	14	14	7A	14A	21
AUSTRALIA	21	21	14	14	14	14	14	14	14	7A	14A	21
CANAL ZONE	21	14A	14	14	14	7	14	21	21	21	21A	21
ENGLAND	7A	7	7	7	7	7	14	14	14	14	14A	14
HAWAII	21	21	14	14	7A	7	7	7	14	14A	21	21
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MEXICO	21	14	7A	7	7	7	7	14	14	14	14A	21
PHILIPPINES	14	14	14	7B	7B	7B	7B	7B	14	14	14	14
PUERTO RICO	21	14	14	7A	7	7	14	21	21	21	21	21
SOUTH AFRICA	14	14	7	7B	7B	7B	14	14A	21	21	21	14A
U. S. S. R.	7	7	7	7	7	7B	7B	14	14	14	14	7B

WESTERN UNITED STATES TO:

ALASKA	14	14	14	7A	7	7	7	7	7A	14	14	14
ARGENTINA	21	21	14	14	14	7	14	14A	21	21	21A	21A
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SOUTH AFRICA	14	14	7	7	7B	7B	7B	7B	14	14	21	14A
U. S. S. R.	7B	7B	7	7	7	7B	7B	7B	14	14	14	7B
EAST COAST	21	14	14	7	7	7	14	14	14	21	21	21

A = Next higher frequency may be useful also.
B = Difficult circuit this period.