amateur
73 radio

#120
One Dollar
October
1970

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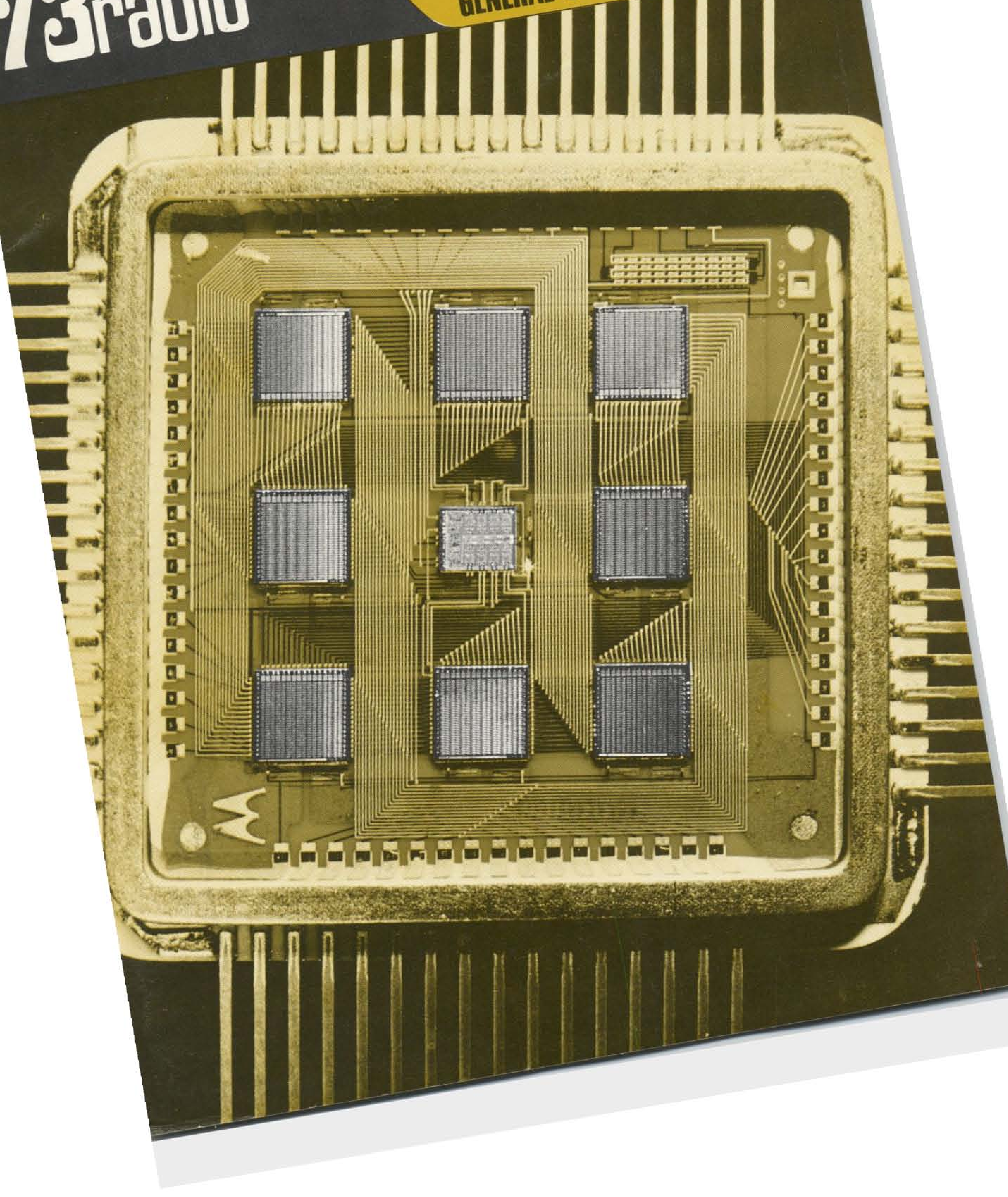

NOTHING COMES CLOSER THAN THE SWAN 500CX

The performance of the Swan 500CX in your car may not quite equal your home station, but you will be amazed at how often the difference is very small. Many Swan mobile operators have established enviable DX records. QSL cards on file here at the factory verify solid contacts from all continents, including stations in Antarctica.

Old timers who have fought QRM with old style AM equipment have discovered a new world of mobile communication thanks to the power and punch of the Swan 500CX transceiver. The efficiency of the SSB mode coupled with the convenience of transceiver operation and a power level unmatched in the field represent a combination well worth looking into. So if you haven't heard ZL, DU or JA say "stand by, the mobile station," then put a Swan 500 CX in your car this summer!

The 500CX installs conveniently under the dash of most cars, and the power supply goes under the hood. Add the Swan Model 35 high Q single band mobile antenna, or your choice of either the Swan Model 45 or 55 band switching mobile antenna, and you can enjoy mobile operation to the fullest. Home station performance with a mobile rig? Nothing comes closer than a Swan transceiver.

ACCESSORIES:

Model 500CX	**$565**
Model 14-117 DC Supply	**$130**
Mobile Mounting Kit	**$12**
Model 35 Single Band Antenna, from	**$20.90**
Model 45 5 Band Manual Switching Antenna	**$79.50**
Model 55 5 Band Antenna (Remote control band selection)	**$129.50**

See your Swan dealer today.

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#121 October, 1970

amateur 73 radio

Features

Contents

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We do not claim that subscribing to 73 will make you wealthy, yet we cannot overlook the many reports we have received from our subscribers telling us that soon after subscribing to 73 they found buried treasure, fell heir to a fortune, or discovered a pearl in their oyster. It is difficult to overlook the strange coincidence that the magnitude of their windfall seems to always be in direct proportion to the length of the subscription taken to 73. Is a subscription to 73 really a money magnet? Can you afford not to make sure about this?

Amateur Radio News Page

October XIXLXX | Monthly Ham News of the World | 73 Magazine

HAM DOCTORS QSO WITH EARTHQUAKE AREAS IN PERU

Communicating with doctors in the earthquake disaster areas in South America to provide medical aid and with its international ham doctor members were some of the additional activities carried on by the Medical Amateur Radio Council (MARCO) members attending the recent American Medical Association Convention in Chicago. Over 10,000 doctors were in attendance.

MARCO members talked via Hallicrafters amateur radio equipment to fellow doctors in the earthquake disaster area near Lima, Peru and also handled vital medical messages between doctors from all parts of the world attending the AMA convention and their home offices.

The Hallicrafters Company, Rolling Meadows, Illinois, a subsidiary of Northrop Corporation donated the use of the radio equipment to MARCO for its convention. It was the only radio equipment used by the members.

The major purpose of MARCO is to establish personal communications among its members and their ham colleagues for dissemination of factual medical, electronics, and communication information, both theoretical and practical. It was formed in 1966 as a charitable and scientific membership corporation designed to meet the medical–electronics and radio communication needs of its members. It now has over 400 members.

MARCO, headquartered in Manchester, Conn., has identified itself with doctors in the United States, Canada, and other countries in the world where there are doctor hams. The doctor members get to know their colleagues and develop professional, avocational, and social associations.

While attending the recent American Medical Association convention in Chicago, ham doctors communicated with fellow doctors in the earthquake disaster area near Lima, Peru. Each member of the Medical Amateur Radio Council (MARCO) used amateur radio equipment donated for the vital occasion by Hallicrafters. Standing and listening to the voices of doctors from Lima and other parts of the world was Bud Drobish (W9QVA), Assistant Sales Manager of Hallicrafters. MARCO held its fourth annual meeting and conference during the AMA convention. From left to right: Dr. Earle E. Weston (W8BXO), Birmingham, Mich.; Bud Drobish; Dr. Maurice N. Richter (K7UWP), Phoenix,

FCC PETITIONS IN PROCESS

The following is a comprehensive tabulation of amateur petitions now awaiting action by the FCC. Thanks to Bob Chapman (W1QV), ARRL New England Division director.

RM #	DATE FILED	SUBSTANCE
968	3/66	Use of other than 220 MHz to remotely control RACES stations.

1116	3/67	RACES rules, control of nonamateur licensees.
1306	5/68	Expand 10, 15, and 20 meter phone.
1346	8/68	Senior Citizens license.
1349	9/68	Expand phone privileges for KP4 licensees.
1363	10/68	"Advanced" Technician License.
1392	12/68	Permit RTTY speeds of 60, 75, and 100 words per minute.
1429	3/69	Permit F-4 at 144 MHz.
1454	5/69	Allow Techs to use CW, 80 through 10 meters.
1455	5/69	Counterpart call signs.
1456	5/69	Permit Techs to have same CW privileges as Novices.
1477	9/68	Expand phone bands for DX QSOs only.
1478	4/69	Permit 40F2 emission by RACES stations on 144 and 220 MHz.
1479	5/69	Expand Extra phone bands.
1512	9/69	800W output above 420 MHz.
1516	10/69	Tech privileges, 21 MHz Novice band.
1520	9/69	CW and phone segments, 6 meter Advanced band.
1521	10/69	Technician CW privileges.
1526	10/69	Technician CW privileges, 10 meters.
1535	11/69	Technician privileges, 29.5—29.7 and 144—148 MHz; dual holding, Novice and Technician.
1536	11/69	Counterpart call signs.
1538	11/69	Higher RTTY speeds of 60, 67, and 100 wpm.
1542	12/69	New repeater rules.
1544	11/69	Extra class phone, 40 and 20 meters, or expand 20 phone for Extra.
1550	1/70	Expand phone bands, 80—15, half for Extra, half for Advanced.
1568	2/70	Novice privileges for Technicians.
1590	3/70	"Grandfather" old Extra Firsts.
1591	3/70	One-year wait for Extra.
1593	3/70	Amend incentive licensing frequency allocations.
1597	4/70	1 x 3 call signs for new Extras.
1602	4/70	Novice privileges for Technicians.
1603	4/70	Expand phone for Extra and Advanced.
1604	4/70	Change ID rules for short QSOs.
1614	3/70	Expand phone bands for Advanced and Extra; widen General Class phone; permit Techs on 28 MHz.
1615	3/70	Conditional Class limited to one year; no new Technician; create Intermediate and Communicator licenses.
1616	4/70	Expand phone, abolish reserved bands.
1629	5/70	Create a military examining point in Germany for FCC amateur exams.
1631	5/70	Specifically provide for discussion of political matters and other controversial subjects in the amateur bands.
1633	5/70	Create a "hobby" license 220.5—224.5 MHz, 5 kHz FM, FM, 100W, mail exam on rules only, NA1—NZØ call call signs.
1644	6/70	Expand phone bands for Advanced and Extra; widen the General portions of the present phone bands; reduce Novice band on 15 to 21.1—21.2, but add a new one 28.1—28.2; permit Extra class to use 7075—7100 kHz for SSB and add a note to the rules restricting 7100—7300 Hz work to Region 2 only.

For copies and additional information on these petitions, write to: (refer to RM numbers)

Amateur and Special Services Division
Federal Communications Commission
Washington, D. C. 20554

Ariz., Dr. William L. Sprague (WA6CRN), Whittier, Calif.; Dr. Walter Shriner (W9CBG), Springfield, Ill.; Dr. Edward A. Holyoke (WA0VSR), Omaha, Nebraska; Dr. Orin Q. Fling (WAZWAU), Delhi, N.Y. Sitting is Dr. J. Stanley Carp (K1EEG), Saugus, Mass. and directly behind him is Joseph G. Boris, Executive Secretary of MARCO.

QSL Manager of the Month

George Studd (ZL2AFZ) has been named QSL Manager of the Month by Scotty (WA5UHR), who makes such awards periodically on behalf of his QSL service.

According to Scotty, George is a great DX'er and a credit to our hobby. Along with several DXpeditions, he has traveled 45,000 miles, covered 33 states, 6 Canadian provinces, and visited the north Arctic circle and Alaska. When he was in the States he took over 1200 color slides, spoke on 2 TV shows, 2 BC stations, dozens of radio clubs, Kiwanas, schools, churches, etc. George has received a number of DX awards. He is QSL manager for VRIQ, ZL2AFZ/C, ZN1BN/A, ZM3PO/C, AXØLD, ZM1AAT/K, ZL2ANX. He was previously manager for ZL1DS/C, ZL1TU/C, and ZL1IL/c.

Nominations for QSL Manager of the Month should be sent to Scott's QSL Service, 1510 Lynnview, Houston, Texas 77055. Include name and call of manager to be nominated and a short summary of why he deserves to be nominated.

Alabama Hamfest Success

Eight hundred hams and their families braved the summer sun of Northern Alabama to attend the Huntsville hamfest on August 16th. The event, held in the air-conditioned splendor of the Huntsville Mall, was a complete success by any standards.

The hamfest started Saturday night with a talk by Wayne Green giving some perspective to the present situation of amateur radio in terms of its history, the ITU, and the FCC. Slides were shown of his recent trip to Jordan and his visit with King Hussein as well as a previous trip to Nepal. All questions were answered, pertinent and impertinent.

On Sunday there were RTTY displays, FM get-togethers, DX displays, a couple of acres of swap-fest, Bingo for the XYLs, and frequent showings of the Dave Bell film on amateur radio.

FCC REGULATIONS PROHIBIT CONTESTS!

ARRL in Chaos

FCC Amateur Radio Rules and Regulations Part 97.125 says, "No licensed radio operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal."

Could that rule be clearer? No willful interference with any radio signal. That means exactly what it says. If you have even the slightest reason to believe that your signal might cause interference to another signal it is against the rules for you to transmit.

Contests, those giant exercises in willful interference, are obviously absolutely illegal.

The preponderance of contest activity in the U.S. is sponsored and promoted by the ARRL. Since we must assume that the directors and officers of the League are familiar with the amateur regulations, then the only conclusion possible is that they are knowingly promoting and encouraging an illegal activity which causes tens of thousands of amateurs to break the FCC regulations.

DX Pileups Illegal

If it is illegal to cause interference to one station, just think how illegal it must be to cause willful interference to dozens or even hundreds of stations. Think about that the next time you are about to add your potent signal to a pileup calling a rare station. Is working that station really worth the torment you will suffer knowing that you have committed multiple violations of the regulations, not to mention the suffering and anguish you have caused the poor chaps on the channel whom you clobbered. One would have to be a pretty lawless and callous individual to chase DX in view of all that.

W1AW Breaks Regulations

Yes, even sacrosanct W1AW is in continuous violation of 97.125. Just tune in anytime to the broadcasts of League affairs and you will notice that W1AW comes on frequency on schedule and causes willful interference until everyone moves off channel for them.

Is This Serious?

The law is the law and many bleeding hearts feel that all laws should be observed, no matter how inappropriate they may be. When a law is bad the question arises, should we ignore the law or try and change it?

The idea behind 97.125 is fine and the law will cause little trouble if everyone continues to ignore that it exists. Unfortunately, the lid has been opened recently by the FCC. Two amateurs, both calling a third station simultaneously, with the goal of seeing which had the strongest signal, received an FCC citation citing 97.125.

The cure is simple. If one of you will write a letter to the FCC, with the usual 14 copies, asking that the words "willful or" be removed from 97.125, then we would have the same law, but without the bad part.

New DX Certificates Available from 73

WORKED NORTH AMERICA

Card confirming two-way contact with amateurs in each of the following areas must be furnished: W1 through WØ, KL7, VE1-8, including separate cards for PIE, CBI, NS and NB in VE1, FP8, VP7, and both Yukon and NWT in VE8, a total of 27 cards. Cards should all be dated 1970 or later.

WORKED CENTRAL AMERICA

Cards confirming two-way radio contact with amateurs in each of the following areas must be furnished XE1-2-3, XF4, VP1, TG, YS, HR, YN, TI, HP, KZ5 (a total of 12 cards). Cards should be dated 1970 or later. It

DX NEWS ROUNDUP-NEWS FROM ALBANIA

From the West Coast DX Bulletin comes this late report filling in details on the OH/ZA effort. The OH group drove by car some 700 miles to Copenhagen and flew directly from there to Tirana. No answers had been received to their letters of inquiry for information and they went on the trip to see what might be accomplished. At customs they were passed through without any examination and they carried their rig to their hotel. They then learned that they would not be permitted to go on to Tirana. With the help of their Albanian guides they set up their antenna and started working the pileups. This lasted for about nine

During the balance of the stay the OH group tried to get a special visa to visit Tirana and discuss the situation. Direct efforts did no good, but finally the Albanian guides were persuaded to make arrangements which would permit them to visit the Albanian capitol. They went there on the last day of their stay and had a one hour meeting with the vice director of the Ministry of Communications. They learned that their letters had been received, but had not been answered because there was no provision for amateur radio in Albanian law, it being neither allowed nor prohibited. He asked that more information be sent before any future

Rogues Gallery. *This photo of C. R. Lander (ZL3ACY) won first prize in a recent competition sponsored by the North Canterbury Amateur Radio Club, Canterbury, New Zealand. As winner, Lander received a subscription to 73 Magazine and his photo appeared in several international publications.*

is the areas that are important, so special call prefixes are acceptable.

WORKED THE CARIBBEAN

Cards confirming two-way amateur radio contact with each of the following areas must be furnished: KS4 Swan Island, KS4 Serrana Bank, KS4 St. John, VP2M, VP2S, VP2V, VP5, FG7, FM7, FS7, PJ St. Martin, PJ St. Eustatius, PJ Aruba, PJ Curacao, PJ Bonnaire, PJ Saba, 8P6, 6Y4 Trinidad, 6Y4 Tobago, YVØ, HKØ San Andres, HKØ Baja Nuevo. Cards should be dated 1970 or later. Certificates are available for 20, 30, and 40 areas worked.

WORKED SOUTH AMERICA

Cards confirming two-way amateur radio contact with each of the following areas must be furnished: HK, YV, PZ, SR, FM7, PY, LU, AP, CE, HC, OA, CP and CX, a total of 13 countries. All cards must be dated 1970 or later.

WORKED EUROPE

Cards must be furnished confirming two-way amateur radio contact with each of the following areas: G, GM, GW, GI, GC Jersey, GC Guernsey, GD, EI, F, D, DL7, DM, EA, EA6, FC, C31, HB, HE, OE, OK, HA, YU, OZ, LA, SM, OH, OHØ, OJ, CT, YO, AZ, SV, SP, I, M1, HV, IS, IT, SVØ Crete, SVØ Dodecanese, LZ, TF, OY, ON, PA, LX, ZB2, 4U (Geneva), 9H1, TA (European), SMOM, JX, JW Svalbard, JW Bear, UA2, UA, UB5-UT5, UC2, UD6, UF6, UG6, UO5, UP2, UQ2, UR2, a total of 65 areas. Certificates are available for 50, 60, and 65 areas.

Contacts may be made on any amateur bands using any mode. All cards must be dated not earlier than 1970. Send cards with note describing certificate applied for and listing the areas confirmed along with one dollar to cover the cost of handling. Send to 73 Magazine, Peterborough, N.H. 03458. Foreign amateurs may apply through their national societies and send along an affidavit attesting to the inspection of the cards and seven IRCs.

hours.

The next morning the Albanian authorities were at the door, apologizing for not having noted the declaration of the radio gear on their entry. They advised that the bringing of radio into the country was prohibited and the equipment would have to be held until they left the country. The operation was over by 0700Z on July 11th. trip and asked that the information be sent two months in advance so arrangements could be made.

The Albanians had apparently set up a monitoring station about 200 yards from the hotel before the visit. The transmissions were recorded and checked by English-speaking Albanians. The OH group kept all transmissions in English, commenting favorably on the Albanians and their treatment at frequent intervals. Whenever they left the hotel they were followed. Why was the rig impounded? Perhaps the authorities wanted to examine it or possibly they were not anxious to sit and monitor the pileups for a full week. It was returned in good condition. In retrospect the OH group felt that the decisive factor in the future Albanian attitude would be what benefit the country might derive from amateur activity.

Looking ahead, the OH group are making plans for another effort in June 1971. Documentation has been forwarded to ARRL and DXCC credit is expected. Some 600 W/K's were worked. The OH group is grateful to the International DX Association for making a modified HW-32 available for the trip.

Canada–Sweden Reciprocity

Ottawa. Canada's director of Telecommunications, Mr. W. J. Wilson, has announced that his country is now recognizing reciprocity with respect to "temporary amateur operating privileges with Sweden." For Swedish permits issued for a period of less than 30 days, Wilson stated, the fee is 40 Swedish kroner. Wilson also supplied the following excerpt from the Code of Statutes of the Swedish Telecommunications Administration:

Any foreign radio amateur applying for a temporary permit . . . shall submit his application via the authorities issuing permits in his native country, which authorities will forward it to the Central Administration of Swedish Telecommunications together with their comments. The application, which may be written in Swedish, Danish, Norwegian, English, French, or German, should be submitted early enough to reach the Central Administration not later than two months before the permit is required. It shall be accompanied by a certificate of good conduct issued by the police authorities of the applicant's native country.

QSL Delays

A note from Garth (5H3LV/A) explains that QSLs for the Zanzibar expeditions have been delayed a bit due to their being sent to U.S. QSL bureaus during a Canadian postal strike.

A cable from King Hussein tells us that all QSLs for JY1 have been forwarded through the bureaus.

While most of the individual bureaus work quickly and efficiently, the biggest holdup seems to be at ARRL headquarters, which reportedly holds cards up to six months or so before sending them along to the individual bureaus.

Haiti Active for DX Contest

by W6GC

W6WLH, W6EJJ, and W6GC will be operating HH9DL during the CQ worldwide DX contest on October 24 and 25. They will operate 5 bands, 10 through 80 meters, for the entire 48 hours of the contest. There are no particular frequencies chosen as yet, but some operation will be outside the American phone bands using split frequency. For a part of the time the listening frequency will be in the General portion of the bands so everyone will have a chance.

This is reportedly the first time any Haitian station has operated the contest. The group plans to arrive in Haiti about October 20 and will be on the air both SSB and CW for about 3 days before the contest.

Canada–U.S. CB Reciprocity

Under an agreement between the United States and Canada, effective July 24, 1970, visiting Canadians who hold valid Canadian licenses in the general radio service may request permission to operate their radio stations in the United States.

Permission to operate their radio stations in the United States may be requested by completing an FCC Form 410 until November 1, 1970, at which time a new form 410-B will be available for this purpose. All applicants for such permission must have read and understood Part 95 of the Commission's Rules and all operation must be in compliance with these Rules. Canadians while operating in the United States under such authority must identify their stations by their Canadian call sign followed by the station's geographical location (city and state).

73's New Award Lineup

A whole new spectrum of certificates are being awarded by 73 for amateurs who manage to fulfill the stated requirements – which won't be easy.

Worked the ARRL Certificate

This award is available to any licensed amateur who can provide proof of contact with any four of the current sixteen ARRL directors, all within one year of the date of application. Stickers are available for proof of contact (within one year) of eight or twelve directors, with a special sticker for proof of contact with all sixteen directors. A special sticker is available for proof of contact with John Huntoon W1LVQ, manager of the ARRL, at any time on any band.

Please send $1 to cover costs of postage and handling of this award or sticker. 73 will consider it a news event of the first order when the first 16-director certificate is awarded and asks that you have a photo of yourself and your shack available, along with a brief biography and a story on how you accomplished the seemingly impossible.

Worked CQ Certificate

A beautiful illuminated certificate is available to any licensed amateur who can provide proof of contact with the editor and managing editor of CQ Magazine, K2MGA and K2EEK, both within one year of the application for the award and both through chance, not scheduled contacts. Please send $1 to cover the costs of mailing and handling. . .and good luck!

Worked Ham Radio Certificate

A new and exciting award is available for licensed amateurs who can

Worked QST Certificate

In an effort to promote activity on our amateur bands where little or none existed before, and to bring prominence to a handful of amateurs who were almost completely obscure, despite their untiring efforts to be well known, we are offering a set of awards suitable for framing. Probably the rarest of all of awards will be this gem, available to any licensed amateur who can provide undeniable proof of contact over the air on a chance, not scheduled basis, with both the editor and managing editor of QST, W1LVQ and W1CUT. Both contacts should be within one year of the application for the award. Please include one dollar to cover the costs of mailing, handling, and medication for any ill effects caused by anoverstraining of credulity by the 73 staff.

MALL DISPLAY

To Increase Public Ham Awareness--

Several radio clubs in the Southeastern Pennsylvania area have gotten together for the purpose of putting on a display of amateur radio equipment, and uses of ham radio in helping the nation and public. The display will be known as the "MacDade Mall Amateur Radio Display" and will be held Sept. 17–19 at the MacDade Mall, Glenolden, Penna.

Several MARS stations will also be in live action.

Hallicrafters Wins Cleveland FM 2-Way Contract

Lieut. Gen. Benjamin O. Davis, Jr., Director of Public Safety, City of Cleveland, points to a diagram of Cleveland's new police communications network. A vital link in the system will be the new HC-400, UHF portable radios for which Hallicrafters was awarded a contract. Shown at the extreme left: Lewis Coffey, Cleveland police chief holding the Hallicrafters HC-400 with which his policemen will be equipped; Walter Sutter, Hallicrafters vice president and general manager; Safety Director Davis; and Bob Long, Hallicrafters' Sales Manager.

provide proof of contact with both the editor and publisher of Ham Radio magazine, W1NLB and W1DTY, both within one year of the application for the award and both through chance, not scheduled contacts. Please send $1 to cover the costs of mailing and handling.

Worked 73 Certificate

If you manage to get contact and, even more difficult, get a QSL from both W2NSD/1 and K6MVH/1 you have the privilege of sending in one dollar for a certificate of questionable value which may lend some dignity to your effort. Contacts should be within on year of the application and be through chance, not schedule. Don't forget the dollar. . .we won't.

K3WAS Award

On Wednesday, 11 November, K3WAS, a military amateur radio station at Aberdeen Proving Ground, Maryland, will be operating in conjunction with Veterans Day. A very attractive commemorative certificate will be mailed to all persons who contact K3WAS on this day. The operating schedule is as follows:

50.3 MHz +.3 MHz 0001–2300 GMT
14.320 MHz ±10 kHz 0001–2300 GMT
7.280 MHz ±10 kHz 0001–2300 GMT
3.970 MHz ±10 kHz 0001–2300 GMT

To qualify for a certificate, just make two-way contact with K3WAS and send QSL card to K3WAS, Special Services Craft Branch, Aberdeen Proving Ground, Maryland 21005.

"Big Blow" Award

The Windblowers VHF Society will sponsor the 16th annual "Big Blow" contest on Saturday, September 19, 1970 from 13:00 to 20:00 EDT. There will be four stations operating on 2 meters. Certificates will be awarded to those contacting all four stations.

Location and call letters will be as follows:

W2ZDR/2 Washington Township, NJ
W2RRP/2 Sam's Point, NY
WA2ZAU/1 Topstone, CT
W2ERZ/3 High Knob PA

TAWAS Hamfest

The Iosco Amateur Radio Club is again presenting its Annual "Tawas Hamfest" in Tawas City, Michigan this year. The affair will be featuring a gigantic "swap & shop," equipment displays, banquet, Ham-of-the-Year award, and auction. The hamfest will take place on U.S. 23, 60 miles north of Bay City. Plenty of activities for the ladies, such as: boat trips, air base tour, ladies luncheons. Bring the family for a weekend of fun. Addition information: Hamfest, Box 3321, Jeff. Sta., Detroit, MI 48214.

"HISTORICAL" CONFERENCE SLATED

National Amateur Historical Radio Conference, Canandaigua, NY, Oct. 9th and 10th, sponsored by the Antique Wireless Assn. Program includes well known speakers from coast-to-coast, early transmitting and receiving demonstrations with prizes plus old equipment auction. In addition to amateur programming, there will be special events for the oldtime commercial and broadcast operator. Write for details: Lincoln Cundall, W2QY, 69 Boulevard Pkwy., Rochester, NY 14612.

The City of Cleveland, Ohio has awarded Hallicrafters Co. a contract for approximately $750,000 to supply Model HC-400 FM 2-way portable radios operating in the newly expanded 450 MHz frequency band for its police department's new communications system.

When signing the contract, Lt. Gen. Benjamin O. Davis, Jr. (U.S. Air Force, retired), Director of Public Safety, City of Cleveland, said that the Hallicrafters award was based on the "most cost effective bid" submitted for portable FM units. Hallicrafters was awarded the Cleveland portable radio contract in competition with Motorola and the General Electric Co.

The new HC-400 is small, light, and utilizes integrated circuits and the newest discrete components. Helical resonators are used instead of coils in critical rf circuits to give the high performance required in the newly assigned UHF frequency bands.

The 856 UHF type radios to be supplied (Hallicrafters Model HC-400) are an advanced communications design developed by Hallicrafters engineers. Each unit is battery operated and provides a minimum of 2W rf power output with a battery life of 8 hours at a 10–10–80% duty cycle. Each unit has 4 transmit and receive channels and is equipped with continuous tone squelch. The Cleveland version of the Hallicrafters HC-400 utilizes an external wearable speaker/microphone/antenna combination. All three functions are combined in a compact unit that can be handheld or worn on a quick-disconnect patch attached to a policeman's uniform.

The Hallicrafters HC-400 personal portable FM 2-way radio is designed to work as an integral part of the "new trend" Cleveland police communications system operating in the UHF band. The prime contractor for the system is Page Communications Engineers of Washington, D. C.

Morro Bay Award

The Estero Radio Club of Morro Bay, California, announces the Morro Bay centennial award, in honor of Morro Bay's 100th year. The centennial celebration runs from July 1970 to July 1971. Contacts for the award must be made within this period. To obtain the award, work eight stations in San Luis Obispo County, including three members of the Estero Radio Club. Any mode and any band may be used.

The members of the club include – K6TOE; WB6s: BNF, JTA, STG, TYR, PPZ, ZRR, ECM, ROG, PGK, SBH, VKN, YCH; WA6s, DDQ, DEI, FHV, GOR, MGG, QDA; and WN6s, DHS, KOG, NFB.

Send a list showing stations, times, and frequencies and $1 to WA6DEI, custodian, Box 1118, San Luis Obispo, CA 93401.

If It Ain't One Thing It's Another!

Two issues back 73 published a new-product writeup describing the FM Schematic Digest, a comprehensive sourcebook of Motorola transmitter, receiver, and power supply schematics. The only trouble with the writeup was that a price of $3.95 was quoted, while the *actual* price is $6.50. As might be expected, myriads of customers complained to the publisher that they had been overcharged. The publisher, in turn, asked 73 to rectify the situation by printing a retraction. This is it. Please, all you FM enthusiasts out there in Radioland, stop bugging the people at Two-Way Radio Engineers, Inc., 1100 Tremont St. in Boston. It wasn't their fault. Besides, $6.50 is a mighty good price for 136 extra-large pages of Motorola circuit diagrams, alignment dope, and crystal ordering info.

Classified

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. . .

FOR SALE: Brand new Gonset Communicator IV, 2 meters. Complete with manual, $250.00. Certified check or money order. Tim Gysan, 53 Lothrop St., Beverly MA 01905.

TIME BASE CRYSTAL OVEN. Center temp. 75°C. Cycling .05°C. 115V ac. 1½" dia. x 3" tall. Octal base. Holds HC-6/U xtal. Made by Ovenaire. Replacement for Berkley Counters. $10.00 includes shipping. Never used. Guaranteed. Yellow Cab Radio Dept., PO Box 587, Kansas City MO 64108.

SELLING: $230 of radio gear. Hallicrafters SX120 general receiver, $30; October 24, there will be a get-together and technical program presented. There will be no charge or other fee made to attend. For particulars write A. C. Harbin WA5LWT, 204 Cedar, Brownfield TX 79316.

BEST OFFER: Hammarlund HQ-110, Heathkit supply HWA-17-1, Monarch FS1-3, B&W 75 ohm filter, 73 Magazine from 1st copy. Roy A. McCarthy K6EAW, PO Box 3712, Anaheim CA 92803.

SWAN 250, 117 xc supply, TV2B (new), SB500 transceiver, Clegg Venus xcvr, 416 ac supply. SASE for details. Scotty, 14534 Vaughan, Detroit MI 48223.

HW12, 22, 32. Owner: Convert your rig to three band SSB/CW transceiver. Construction manual, $3.00 ppd. Camelot Company, 215-28 Spencer Avenue, Queens Village NY 11427.

NATIONAL 1000, one kilowatt transceiver, 80—10 meters, brand new, used for short test for 73. Cost $1100. Send check for $900 and it is yours. Factory guarantee. 73 Magazine, Peterborough NH 03458.

AMATEUR EQUIPMENT REPAIRED, calibrated, kits assembled and aligned, de-bugged by holder of Amateur and First Class Commercial FCC licenses. Write Tom Hopkins, Box 396 Faison NC 28341.

FACSIMILE MACHINES: RD92A/UX and TXC-1B. Your choice, with 100 sheets paper, $125.00. Need Mite motor. F.K. McGinnis, 4304 McFarlin Blvd., Dallas TX 75205.

WANTED! Numerous back issues of different radio magazines. Huge Free List. Trading old radio shows, airchecks, interested in commercial movie material. Thomas King, Auxier, Kentucky.

DRAGON FLY. . .antenna, for 20-40-75 meters. . .no traps. . .no compromise. . .eight months in development. . .one feed line. . .SWR one to

SWAN 250, power supply, xtal calibrator, S-meter, in original cartons $300. Getting TR-6. K1FMU/WB8FVL George Dessert, RFD 4, Parkersburg WV 26101 (304-863-5405).

SWAN 250, power supply, xtal calibrator, S-meter, in original cartons $300. Getting TR-6. K1FMU/WB8FVL George Dessert, RFD 4, Parkersburg WV 26101 (304-863-5405).

WANTED: Used MN-2000 Drake Matching Network. Must be in mint condition and reasonable priced. Edward Kovalan, 227 Wildwood St., Clarksburg WV 26301.

GREAT BRITAIN to the U.S.A. Let us quote you for any equipment or components. Free lists available. Enquiries answered by return Air Mail Post. We require good clean job stocks of electronic components. Elekon Enterprises, 12A Tottenlam St., London WIP 9PQ, England.

GET YOUR "FIRST!" Memorize, study—"1970 Tests-Answers" for FCC First Class License, plus "Self-Study Ability Test," Proven. $5.00. Command, Box 26348-S, San Francisco CA 94126.

TEST EQUIPMENT: Signal Generators: Meas. 80, 2—400 MHz, $250; URM26A, 3—405 MHz, $225; Meas. 65B, 15 kHz, 50 MHz, $350; HP608A, 10—500 MHz, $425. Counters: Berkeley 5500, Univ. EPUT, 100 kHz, $165; HP524B, 10 MHz, $495; HP525A, 10—100 MHz plug-in, $115; HP626B, Time Interval plug-in, $95. All guaranteed. Many more, send SASE for list. Grattan Gray, PO Box 941, Monroe MI 48161.

NEW SB 400 xmtr w/xtal pak, never used and factory aligned, $300; NC 303 reconditioned and beautiful, $200; Collins mint KWM1, ac, dc, and mobile mount, $325; Collins KWM 2, 6 months old with CC2 case and ac power, $750. Need 2 kW linear and will swap. WB8FUG, PO Box 23, Conway MI 49722.

LISTING SERVICE — gear to sell? Need rig? Sellers, $1.00; lists information year. Buyers, free. SASE brings details. W8TXX listing service, Box 1111, Benton Harbor MI 49022.

DTL INTEGRATED CIRCUITS: Guaranteed new: gates 70¢, buffers 80¢, F/F 90¢, dual F/F $1.15. Add 20% postage. SUMMER SPECIAL: subtract 10% discount, September only. Mitch-Lan Electronics Co., Dept. 1070, PO Box 4822, Panorama City CA 91402.

TECH MANUALS: R-390/URR, R-390A/URR, TS-186D/UP, BC-639A, R-274/FRR, ARR-7, $6.50 each; TS-174/U, TS-175/U, TS-323/UR, $5.50 each. Hundreds more. S. Consalvo, 4905 Roanne Drive, Washington DC 20021.

RG8U or RG11U: Low loss foam coax 10¢ foot. PL259, SO239 40¢ each. 15/$5.00. Jacketed ½ inch aluminum 50 ohm Foamflex 20¢ foot. New Ham-M Rotor $95.00. Everything new! Monte Southward, Co. RD 51, Upper Sandusky OH 43351.

FOR SALE: Best offer DX 100, SX100, DX 40, Globe 90, TBS 50, BC 348, RCA 88LF, ip501, Marconi LF, Omega 4x5 enlarger, HT40 RCA 8506B, AR 8503, all in working condx. Write Box 8352, Savannah GA 31402.

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

TELETYPE PICTURES FOR SALE: Volume 2, 16 pages containing 50 pictures $2.00. Volume 3 coming $1.50. Also audio and perforated tapes. W9DGV-c, 2210-30th St., Rock Island IL 61201.

TAMPA HAMFEST Lowry Park, Sligh Ave & Norht Blvd., Tampa, Fla., Sunday, October 11, 1970. Lots of prizes; plenty of free parking. Fun for all.

Heathkit HW30 twoer ground plane and beam, $50; Clegg 99er for six meters and Drake T100 high-pass filter and six meter beam, $90; antenna rotator and mast, $60. Howard Applegate, 159 Sheridan Square, Brigantine NJ 08203. Phone: YO9-266-3106.

CHARTER JET FLIGHT to SAROC. Roundtrip New York City to Las Vegas $229.00, depart JFK 10:00 a.m. January 7th. Roundtrip Chicago to Las Vegas $199.00, depart O'Hare 12:00 noon January 7th. Return January 10th. Includes meals and drinks aloft, Flamingo Hotel Room three nights double occupancy, transportation and baggage in and out of Flamingo Hotel, dinner show, midnight show, Saturday buffet luncheon, Sunday buffet breakfast, SAROC tickets, tax and gratuity. $60.00 will confirm reservation, includes one dollar service fee. Final payment due before November 25th. Flight cancellation or written request for deposit refund will be accepted until December 1st. SAROC, Box 73, Boulder City NV 89005.

ATTENTION: Galaxy V Mark 2, A.C., Console, V.O.X., $370. Gonset G-50, $150. CV-71 T.U., Lab Aligned, $65. Bill Handel K8SSY, 95 Murwood Drive, Chagrin Falls OH 44022 (216-247-6130).

HIGH-POWER MOTOROLA Handie-Talkie Motorola PT 300. Practically new. Two frequency. Tuned up and operating perfectly on 146.76 and 146.94. Includes mashbar handset with curlycord, crystals, new nicad rechargeable battery, battery charger. Puts outs about 6.5W. Receiver sensitivity 0.25 μV. A steal at $325 and the first check buys it. Manual included. Ken Sessions, 73 Magazine, Peterborough NH 03458 (603-924-3873).

TERRY COUNTRY AMATEUR RADIO CLUB will hold its 16th Annual Hamfest and Swapfest on Sunday, October 25, 1970 in the National Guard Armory, Brownfield, Texas. For those who come early on Saturday one guaranteed. Construction drawings $5.00. Box 423, Wakefield RI 02880.

RBB-RBC MANUALS, New, $5.00; Used, $4.00. OS-8 oscilloscope manual, $3.00. Some QST 1929, 30, 31, etc. Radio 1939, 40, 41, etc. Write for list. James W. Holloway W6LFL, 2027 Harton Rd., San Diego CA 92123.

SAROC January 7–10, 1971, Flamingo Hotel Convention Center, Las Vegas, Nevada. Sponsored by Southern Nevada ARC, Inc., Box 73, Boulder City, Nevada. Advance registration $14.50 per person accepted until January 4, regular registration at door, includes Flamingo Hotel Late Show and drinks, Sunday breakfast, cocktail parties, technical seminars and meetings, ARRL, DX, FM, MARS, QCWA, WCARS-7255, WPSS-3952, and WSSBA. Ladies Program. Flamingo Hotel SAROC room rate $12.00 plus room tax, per night, single or double occupancy January 3 thru 12, 1971. Mail accommodations request to Flamingo Hotel. Mail advance registration to SAROC. W7PRM, Club President. W7PBV, SAROC Convention Chairman.

GREENE. . .center dipole insulator with. . .or. . .without balun. . .see November 73, page 107.

SELL or trade for ham equipment: H/P micro-wave instruments; 415B $50, 416B $75, 430C $75, plus shipping. WA8JEH, 23 Coolidge Ave., Columbus OH 43228.

HALLICRAFTER HT-33 kW linear (needs 2 tubes) $75, HT-30 Exciter $75, Drake 1A rcvr. $100, all for $200. Phil Windolph W9NEP, 10737 S. Michigan, Chicago IL 60628.

SELL: Two Synchro Tape Machines (Remington Typewriter/Friden Tape/Card Punch and Reader) $150. Operation instructions and manuals for Friden units only. Some tape and cards included. Complete description in late 1968 issues of 73. Tektronix 511AD $95. Tektronix 514AD $150. Manuals, probes, and some spare tubes included.

30 WATT SSB TRANSISTOR

A new single-sideband transistor furnishing 30W PEP across the 1.5 to 18 MHz band is announced by TRW Semiconductors. The new PT6738 has a gain of 13 dB and intermodulation distortion guaranteed 30 dB or better. Operating voltage is 28V. The unit is in the TO-59 package which is compatible with the TO-60. The new transistor is a product of TRW Semiconductor Division, Communications Transistor Plant, 14520 Aviation Blvd., Lawndale, Calif. 90260.

Representatives from five major distributors of Signal/One's Model CX7 transceiver inspect the new radio in a familiarization seminar at the Signal/One facility in St. Petersburg, Fla.

From left are Otto Hagendorff of Harrison Radio Corp., New York City; Park il Young of Henry Radio Stores, Los Angeles and Anaheim, Calif.; Signal/One's Charles Brock; Doug Murray, owner of Amrad Supply, Inc., Oakland, Calif.; Miles Cundy of Amateur Electronic Supply, Milwaukee, Wisc.; Signal/One's Amory Planchard; and John Capone, owner of CW Electronic Sales, Denver, Colo.

The Signal/One program is a part of the Data Communications Group of Electronic Communications, Inc.

The CX7, described as a "deluxe integration station in a single compact package," incorporates many new design features, most of which stem from the application of advanced aerospace electronic technology to the amateur radio field.

NEVER SAY DIE

...de W2NSD/1

EDITORIAL BY WAYNE GREEN

A note from one of the officials running the ARRL National convention in Boston explained that Huntoon again has forbidden them to allow anyone from 73 to appear on any program.

There being more than one way to skin a cat, we have arranged to have an auditorium room at the convention in which to run our own program. This is more than sour grapes, judging from the number of letters we have had asking if we were going to be able to show my slides of King Hussein, if Ken were going to be able to organize an FM repeater forum to coordinate action for getting the proposed FCC regulations straightened out, etc. There are a number of things that should be brought up for discussion at the National Convention and we intend to bring as many up for discussion as possible.

To those of you familiar with the usual ARRL open forums, let me say that the forums we organize will not be the rigged affairs that you have experienced in the past. I have yet to see an ARRL forum that didn't appear to be meticulously planned with the end of preventing the members from asking any embarrassing questions.

If you have any ideas for forums that would be of benefit to our hobby please take the time to work out some details on your ideas and send them to me.

The schedule of talks in our room . . . room 437 . . . will be available at the 73 booth. Among some of the talks and forums being scheduled are the following:

DX coffee klatch
160–80 DX forum, KV4FZ moderator
Foreign visitor get-together, YO2BO moderator
Forum: Where do we stand with the ITU?
Forum: Do we need more phone allocations?
FM coffee klatch
Forum: FM repeaters and the FCC
Forum: FM the state of the art.
Forum: Do we need a Washington lobby?
Forum: 146.76 or 146.94 as a repeater output?
Forum: DX
Slides: Trip to Jordan and JY1
Slides: Visit to Arecibo and the big dish
Slides: YA-YK-YI-EP
Slides: FK-VR2-5W-KS6-FO
Forum: Mandatory tone for repeater control?
Forum: VHF
Forum: RTTY
Forum: Moonbounce
Forum: New blood for amateur radio?
73 boosters open house (cider–doughnuts)
Forum: Incentive licensing?

It is hoped that all sides will be present for the open forums so that the best thinking of everyone involved can be used to provide solutions to our problems. We plan to record these forums and present the highlights of them in future issues of 73. We will do what we can to see that a representative of the ARRL is present at all forums to provide an explanation of the official ARRL explanation for what has been happening.

Since most of the action of the convention is on Saturday we have scheduled all of the activity on our program for this one day.

Schedule Canceled

In the August issue of 73 I announced that I would be standing by as nightly as I could on 14.300 at 0200 GMT for anyone with any traffic for me, particularly for news items that might be of value for the news pages.

After trying this scheme for a little over a month and meeting the schedule most nights, I can see that it is time to call a halt to this madness. The interference in this General part of the band is beyond belief and more than I care to continue to face. Sure, I can hear the fellows in there calling me, but the noise from other stations is so bad that I can't even get call letters through unless the caller has a kilowatt and a good beam to back him up.

The General class operators who are trapped up in that 75 kHz of the band have more patience than I. The Advanced part of the band is relatively free of interference and the time is rare indeed when I can't find a reasonably clear channel there for working DX. I suppose that it is a lot easier to put up with the mess in the General section of the band than to try and change the band.

It is not likely that I'll be missed too much on 14.300 as one signal more or less on the channel

(cont. on page 31)

Leaky Lines

AN EDITORIAL by DAVE MANN K2AGZ

1 DANIEL LANE, KINNELON NJ 07405

According to a report in a recent issue of Popular Electronics, one of the CB clubs has established an office in Washington for lobbying purposes. The item also states that a nationwide CB organization is probably in the offing, to be coordinated into a program through which they hope to influence the actions and attitudes of FCC. They claim to have an ex-White House staffer and several Texas Congressmen interested in Citizen Band Radio.

There can be little doubt that such an organized lobby, if properly financed and well connected politically, can become a strong force in representing the more than 875,000 persons licensed in that service. But what about us hams? What will happen to the Amateur Radio Service if the CB interests succeed in gaining an inside track, and we continue to go on, living in a fool's paradise?

At 73, Wayne has been advocating a change in perspective for a long time. There are many valid reasons why the American Radio Relay League ought to change its inflexible opposition to the idea of representation in the nation's capital. It is no longer enough to maintain a *laissez faire* attitude toward this necessary change on the sole ground that we must preserve a tax-free status for the organization. While it may be perfectly true that the League saves a great deal of money through this posture, if we were to lose prestige in the eyes of legislators and members of the FCC, merely because of our failure to propagandize (and yes, wheel and deal) with persons who simply do not recognize that there is a vast difference between amateur radio and Citizen Band radio, we are a cinch to wind up holding the smelly end of the shaft. No matter how exalted the position in government a person may hold, he cannot be ex-ected to suck the true picture from his thum There are some very intelligent people who still do not know that we are different from CB'ers, and they actually think that persons who run the little five-watters are ham operators. They simply have no idea that we are a group which participates in a wide spectrum of public service activity . . . and how in the world could they be expected to know the truth if nobody points it out to them?

It has become more urgent than ever for the League to get off its duff and begin to do something about this. We can straighten out our image in short order if only we forget about our own exalted opinion of ourselves. We must get over the idea that we are above getting our hands soiled . . . that we are too good to engage in struggle with our adversaries . . . that we must not show bad manners by sinking to the low level of others. There is absolutely nothing to be gained by sneering and making snide remarks about the 11 meter bunch. While we are scoffing and ridiculing them among ourselves, they might very well be getting some naive Congressmen to pressure FCC for additional frequency grants, and I would just like to ask you, where would that increased spectrum come from? I'll give you three guesses!

We cannot rely upon "The Ham's Wide Wide World" to do the job. It does some good, of course, but it's simply not enough. Ten, twenty, or thirty films like it would also be good, but would not be enough to handle the job. We have got to embark on a much broader program of public education and orientation, which will penetrate into the consciousness and awareness of this entire country. We have got to make sure that everyone in America recognizes that amateur radio contributes toward the general welfare and health of our nation, and it is a viable and indispensable part of our system. We must point out, so that all our people know it unmistakably, that ham radio is not a toy or an idle pastime for a set of superannuated playboys, retirees, and young kids. There are far too many folks in this country who think that ham radio is like stamp collecting, bowling, fishing, kite flying, and other such recreational hobbies. They must be made to realize that amateur radio is a meaningful activity which is vital and necessary to the ongoing development of our society. This can only be accomplished through public education on a wide and universal scale.

It does us little good to proclaim to each other, either verbally or in our own ham publications, which are rarely read by outsiders, how much good we do in programs like AREC, RACES, MARS, or in all our other work. We already know all of that. We don't need convincing. It is the general public and those who represent them in government who must be made aware of it! If we fail to get off our fat behinds and do some missionary work, we may find

(cont. on page 94)

TEMPO one

AN OLD FRIEND (HENRY RADIO) INTRODUCES A NEW NAME . . . A NEW VALUE . . . A NEW TRANSCEIVER. THE TEMPO *'ONE'* SSB TRANSCEIVER REPRESENTS THE CULMINATING ACHIEVEMENT OF MANY YEARS OF EXPERIENCE IN THE AMATEUR RADIO FIELD. MODERN DESIGN, SUPERB PERFORMANCE, HIGH STYLING, STURDY CONSTRUCTION, OUTSTANDING RELIABILITY, EXCEPTIONAL VALUE — ALL THESE FACTORS COMBINED FOR THE FIRST TIME IN AN AMATEUR SSB TRANSCEIVER MAKE THE TEMPO *'ONE'* THE OBVIOUS CHOICE IN TODAY'S AMATEUR MARKET.

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Mr Virgo Himself

Editorial by Ken Sessions

There's an ugly rumor floating around about an idiotic FCC interpretation of what constitutes misuse of spectrum; and if the rumor is proved true, the new bad guys will be the Feds in Washington. And the good guys will include Wayne Green and John Huntoon, as well as all the ham operators who participate in service and medical-aid nets.

The to-do started when the FCC lowered the boom on the eye bank net. According to the Feds' new interpretation of an overapplied ruling, such operations are now illegal. The FCC dropped a note to some of the fellows in the eye bank net and advised them that their hamming was "for the use of" an organization, and was thereby an improper operation.

At the League, Huntoon got wind of the flap and protested to the FCC. The West Coast DX Bulletin also made noises of dissent. But so far the cries have gone unheeded, and the eye bank net – as well as thousands of other service groups – stands on the verge of disbanding. Huntoon voiced his comments to ARRL directors in a general letter last month, stating that the FCC is in effect actually reversing its prior policy of encouraging service organizations.

"These newest interpretations," Huntoon said, "strike at the heart of organized amateur radio in denying our right to continue to engage in such activities as voluntary communications for most boat races, parades, car rallies, charity drives, election results, eyebank network, and the like. . .

And from the West Coast DX Bulletin came the comment: ". . . it would be wise for every amateur – DX'er or otherwise – to watch this matter, keep informed of developments, and support the ARRL in its protests to the FCC."

To give the devil his due, I must say that in this issue, the League must be supported. John Huntoon is right in his reference to the new threat to organized ham radio. The FCC must be made to see that these service functions and organizations are the stuff that hamdom is all about. The consideration that I think should be foremost in the minds of the Feds is the one stipulated most clearly in the FCC rules – about the principal purpose of amateur radio being for the convenience, necessity, and in the best interest of the public.

If the eye bank net is not in the best interest of the community, how can amateur radio itself be? Even the *Saturday Evening Post* has acclaimed the amateur eye bank net for its service to humanity. In a comprehensive story on the workings of the net, Max Gunther's Post article told of how the hams work with surgeons to win the race against blindness. The story goes, in part:

Early in the morning of May 2, 1963, at the Indiana University Medical Center in Indianapolis, a man died of a heart ailment. He was 57. During his lifetime he had become interested in new medical techniques for saving sight, particularly in the fact that parts of the eye can be transplanted from one person to another. Like a growing number of Americans, he had authorized surgical use of his eyes after his death.

The dead man's eyes were promptly removed, sterilized, packed in small glass bottles, and carried to the Indiana Lions Eye Bank in the same building. If, within 48 hours, an eye patient needen them, these eyes could be used. After that, they would rapidly deteriorate.

Later that morning in Iowa City, Iowa, a man visited eye surgeon Dr. Alson Braley. The patient was a dark-haired, handsome young engineer who worked for the Maytag Company in Newton, Iowa. Since his boyhood his left eye had suffered from an inflammatory condition which had damaged the cornea, the transparent outer covering of the eye. On this May morning the eye had suddenly become very painful. Doctor Braley found that the cornea had ruptured, and rushed his patient into the University Hospital. If the eye were not repaired before the day ended, it would be lost.

Doctor Braley's job was to cut out the damaged section of cornea and replace it with a piece of healthy cornea from a donor's eye – if he could find one. He telephoned the local eye bank, but they had no fresh eyes available that day.

Local eye-bank workers might have spent all day telephoning the 80 other eye banks scattered across the nation, and it could easily have been too late by the time the eyes were located in Indianapolis.

Fortunately for Doctor Braley's patient, a more effective link existed – a coast-to-coast network of amateur, or ham, radio operators who make it their hobby to provide emergency communications among the far-flung eye banks.

The staff of 73 joins the staff at ARRL headquarters in an appeal to the FCC to give fresh consideration to federal rulings and official interpretations. All amateurs working in public service and all amateurs who believe that public service is vital to the ultimate preservation of our hobby should voice their opinions to Mr. Bill Grenfell, FCC, 1919 M St. N. W., Washington, D. C. 20554,

. . . K6MVH ■

Robert A. Hirschfeld W6DNS
Section Head, Communication Microcircuits
National Semiconductor Corp.
Santa Clara CA

UNDERSTANDING AND USING INTEGRATED CIRCUITS

The transistor was born amid predictions that vacuum tubes would soon disappear; then, some ten years ago, the first integrated circuits led to speculation that both tubes and transistors would be replaced. While neither of these predictions has yet been completely fulfilled, the last few years have seen substantial shifts towards exclusive use of ICs. It is becoming increasingly profitable for equipment manufacturers to substitute inexpensive, complex "subsystems" for the array of components formerly used, eliminating at the same time much of the assembly work.

For amateur radio, particularly the "homebrew" man, the wide availability of cheap ICs opens up new possibilities. Commercially built ham equipment should simultaneously improve in performance and decrease in cost. As spectrum space becomes more precious, and more sophisticated modulation methods become necessary, ICs will allow uncomplicated design and construction of transmitters and receivers which would have once caused casual weekend experimenters to give up in despair.

What Is an Integrated Circuit?

There's no reason to be mystified. An IC is simply a garden variety transistor circuit, in which a number of transistors,

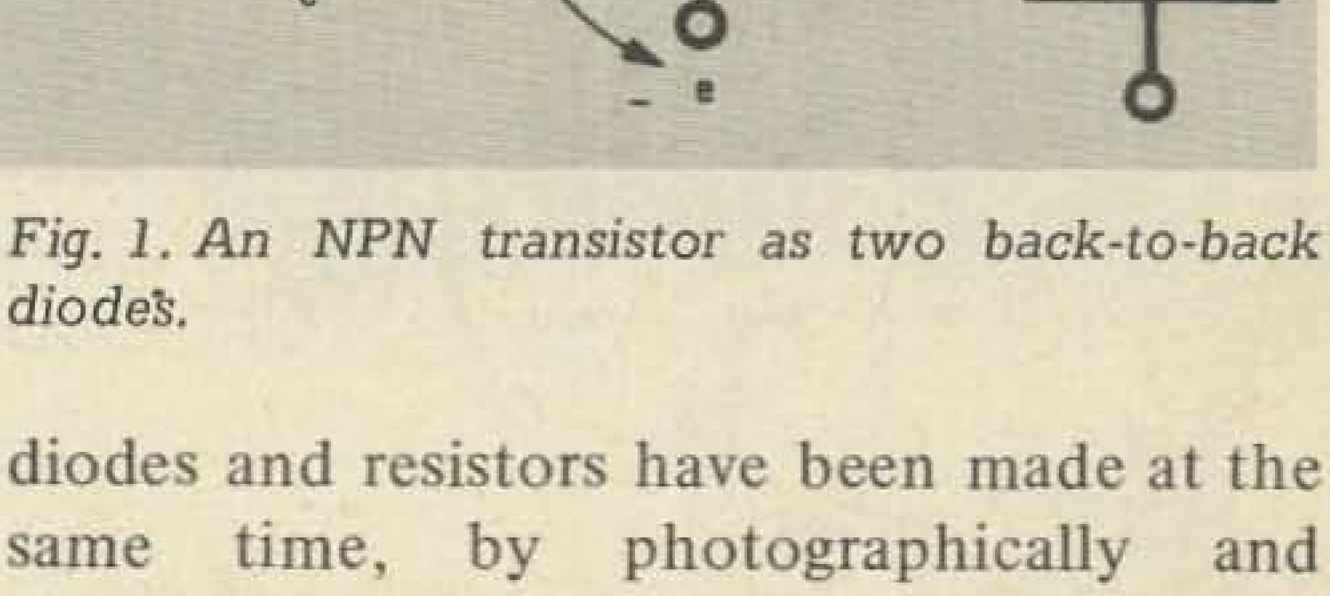


Fig. 1. An NPN transistor as two back-to-back diodes.

diodes and resistors have been made at the same time, by photographically and chemically treating a piece of the base transistor material – silicon. The IC, or microcircuit, is a natural outgrowth of the process used to make single transistors, so let's use the transistor as an IC primer. In its simplest definition, the NPN transistor

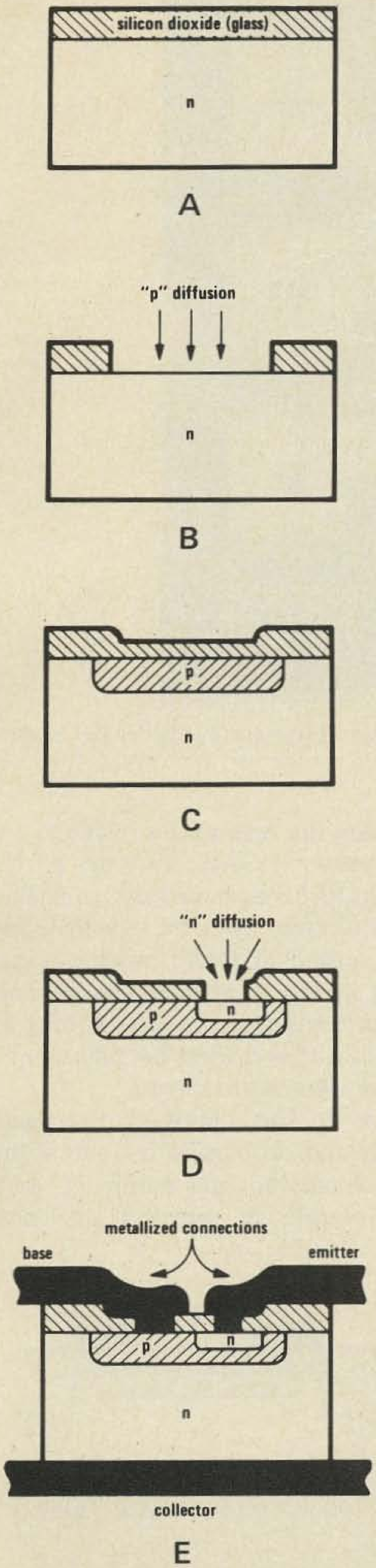


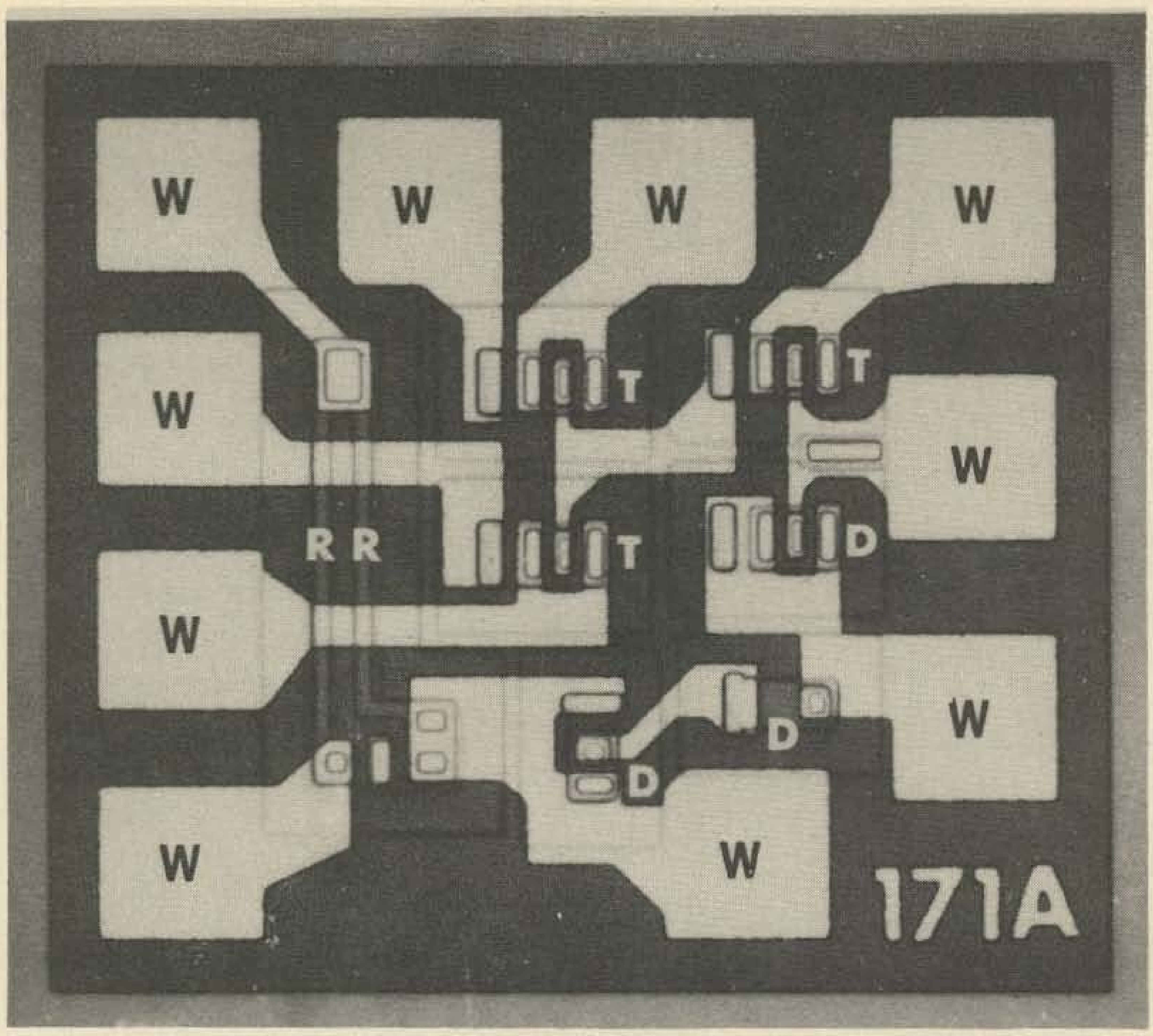
Fig. 2. Construction of a silicon NPN transistor (cross-section view).

of Fig. 1 consists of a forward-biased diode (emitter–base junction), and a reverse-biased diode (collector–base junction), which can be made from a slab of silicon by "diffusing" P- or N-type chemicals, in a high-temperature furnace, into selected regions of the slab.

Assuming that we start with a slab already containing N-type chemicals, Fig. 2A, and chemically "grow" a thin layer of glass (silicon dioxide) on top, the glass layer is now a shield against penetration of the slab by other chemicals. Using the same kind of photo-etching techniques used in the making of newspaper type and photo plates, we make a "window" in the protective glass, Fig. 2B, and then place the slab in a furnace containing P-type chemical gases. The result is Fig. 2C, a "diffused" region under the window in which the majority of atoms are now P-type, plus a regrown layer of glass over the window. A second window, smaller than the first, is opened, and the process is repeated in an N-type furnace, giving the structure of Fig. 2D. Windows are then opened, and contacted by a thin layer of aluminum, for each of the three regions in the slab, Fig. 2E. Attached to wires, and brought outside a can enclosing the slab, these three regions become the collector, base, and emitter. We now have an NPN transistor!

Why make just one transistor? Why not use a photo-etching process that makes many transistors, side by side, on the same slab? This is in fact how most single transistors are made today. Starting with one N-type collector region, many bases and emitters are diffused, with the resultant thousands of transistors, being cut apart afterwards and put in individual packages.

Suppose we want to build other components – for example, a resistor – using the same processing steps employed in making transistors. Why not use the built-in resistivity of the chemically treated silicon as a resistor? And why not cut apart the transistors in interconnected groups, rather than into individual pieces? One problem exists: isolating one element from another. Remember, in a slab, or "wafer," of NPN transistors, all collectors are in one



This photomicrograph of an IC rf amplifier shows NPN transistor elements (T), diodes (D), resistors (R) and the wire bonding pads (W).

region, and are thus shorted together. The solution is a fourth, P-type region, separating each transistor or resistor region (Fig. 3). If we bias this "isolating" region so that it always forms a reverse-biased P-N junction with everything it surrounds, each "component" in the IC will be effectively isolated by a nonconducting, open diode. We can now form any combination of transistors, resistors, and diodes we like, simply by choosing which "windows" we open at each step in the fabrication process.

What Are the Advantages of ICs?

Economy – Since we must go through the photochemical process to make transistors anyway, it costs very little more to make several of them; putting many transistors in one package is more economical than separating them. In the long run, an IC gives a lower "cost per transistor" than a discrete transistor circuit.

Ease of Use – Most of the signal processing and dc biasing is done within the microcircuit, so less wiring is needed to bring signals in and out of individual

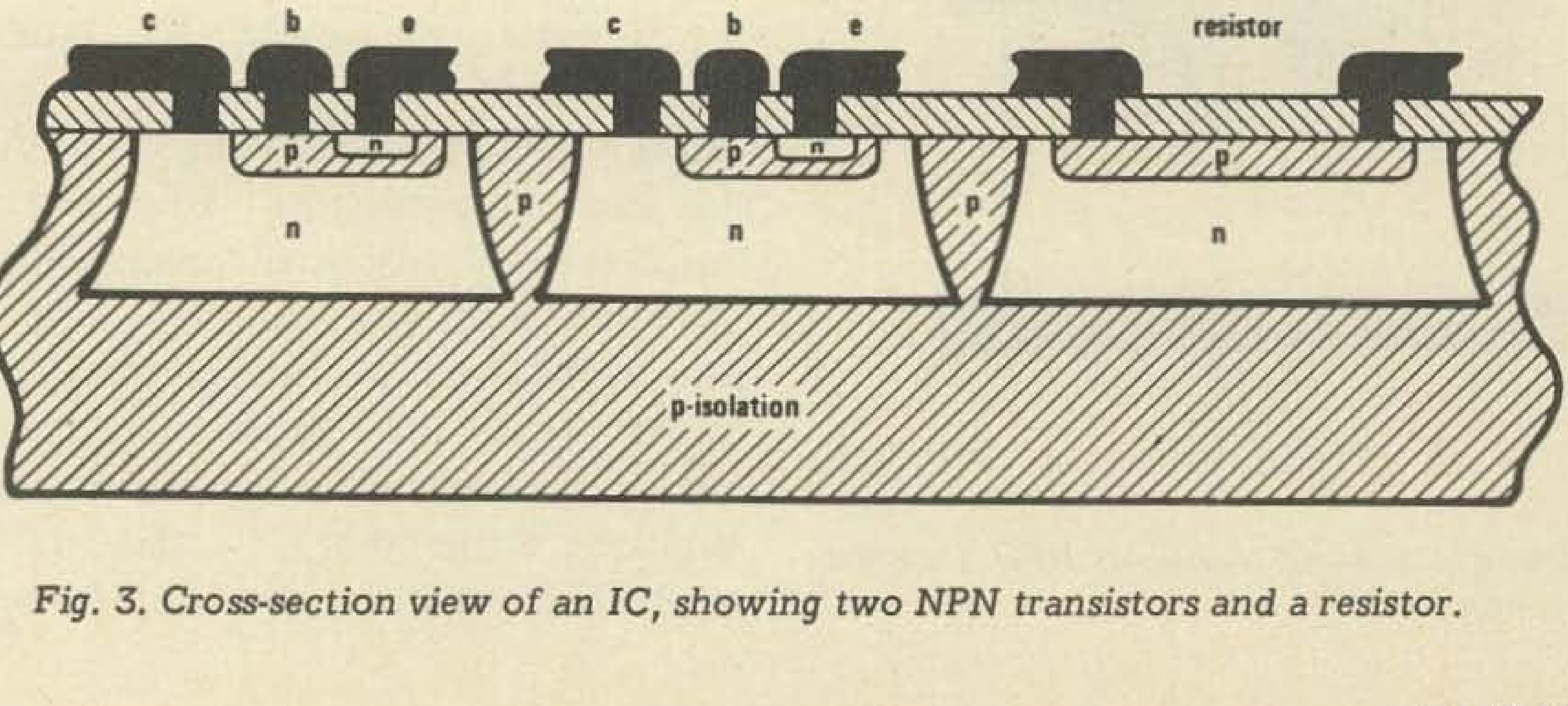


Fig. 3. Cross-section view of an IC, showing two NPN transistors and a resistor.

uses the NPN collector region as base, with P-type emitter and collector formed by two adjacent diffused-base regions. Current flows sideways, or laterally, from emitter to collector. Since the width of the base

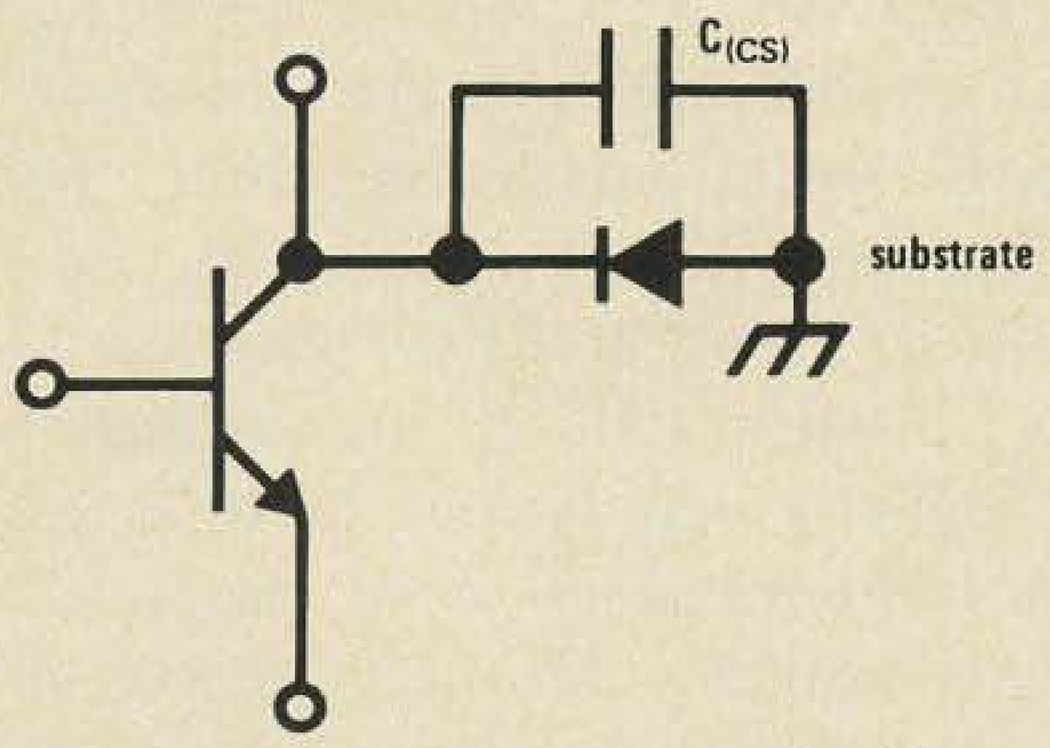


Fig. 6. The "Parasitic" collector-substrate diode.

region is much wider than used for an NPN, the lateral PNP has poor frequency response and a low beta. Thus, lateral PNPs are not used as gain stages, but only as dc level shifters, where necessary. The substrate PNP uses the same type of emitter and base as the lateral; however, its collector is the P-type isolation region, or substrate, which limits the usefulness of this transistor, since its collector is always grounded, and its characteristics as poor as those of the lateral PNP.

Medium-power NPN transistors are now practical; they take up a great deal of chip area because of the need to spread their dissipation over a larger region. Their collector saturation resistance is not as good as very inexpensive "discrete" power transistors, because IC collector contacts are necessarily made from above, while ordinary power transistors, which don't have isolation regions, have bottom collector contacts, with a shorter current path, and hence lower resistance. For most practical designs, an IC can handle power outputs to a watt or so, but must drive an external power transistor to obtain power levels. This also keeps IC power dissipation within the limitations of its small package.

Parasitics – Here is where the actual characteristics of an IC depart in unexpected ways from those of the same circuit in discrete form. The culprit is the P-type isolation region, which separates the various IC elements; it is a reverse-biased PN junction (Fig. 6), which is assumed to be an open circuit. But such a junction produces a parasitic shunt capacitance from NPN collector to ground, which can deteriorate high-frequency performance of the IC. While IC schematics rarely show this PN junction, it must be remembered by the user who applies supply voltage other than those recommended; since the substrate is commonly connected to the most negative point in the circuit, normal operation does indeed keep it reverse-biased, but an attempt to operate an NPN collector more negative than this voltage will forward-bias the junction, drawing possibly destructive currents. Finally, this seldom-mentioned junction can produce undesired substrate PNP action, or even act as an SCR.

Recalling that one definition of a transistor is that it contains a forward-biased and a reverse-biased junction, it can be seen that if the collector–base junction of the NPN is inadvertently forward-biased, it will form the base–emitter junction of a substrate PNP whether we like it or not. Moreover, this condition produces exactly the same trigger condition in the four-layer *NPNP* IC structure as is used to turn on a four-layer SCR. Under some circumstances, this produces "latchup," which holds until the supply is turned off, or draws enough current to damage the IC. In properly designed ICs, used according to manufacturers' recommendations, parasitic problems will not arise. Experimenters, using nonstandard external hookups, however, may find "parasitics" the explanation for the IC's unexpected behavior.

Conclusion

We've peered inside the marvelous, widely acclaimed IC, and found it to be a logical extension of known circuit designs and transistor fabrication techniques. It has a few peculiarities, but offers convenience, performance, and economy in building all types of ham equipment. A basic understanding of what goes into an IC, its advantages and inherent limitations, will prepare us to look at available ICs, and learn how to put them to work.

. . . W6DNS ■

transistor stages, or to interconnect bias voltages.

Performance – As we've seen, there's nothing magic about the individual transistors used in an IC; if anything, they may not be quite as good at high frequencies as their discrete counterparts, because of the capacitance to the "isolation" region. Their real advantage in performance is that we are no longer limited to designing circuits to use a minimum number of expensive transistors; we can design a better circuit that uses four or five times as many transistors, at less total cost than the discrete circuit. Moreover, interstage coupling and capacitance is much less of a problem than with "discretes," because of the microscopic lead lengths between components. Finally, because all parts of the IC are made simultaneously, by accurate photographic techniques, excellent component matching is guaranteed. For this reason, integrated circuits are available which simply are impractical using single, hand-matched transistors and resistors.

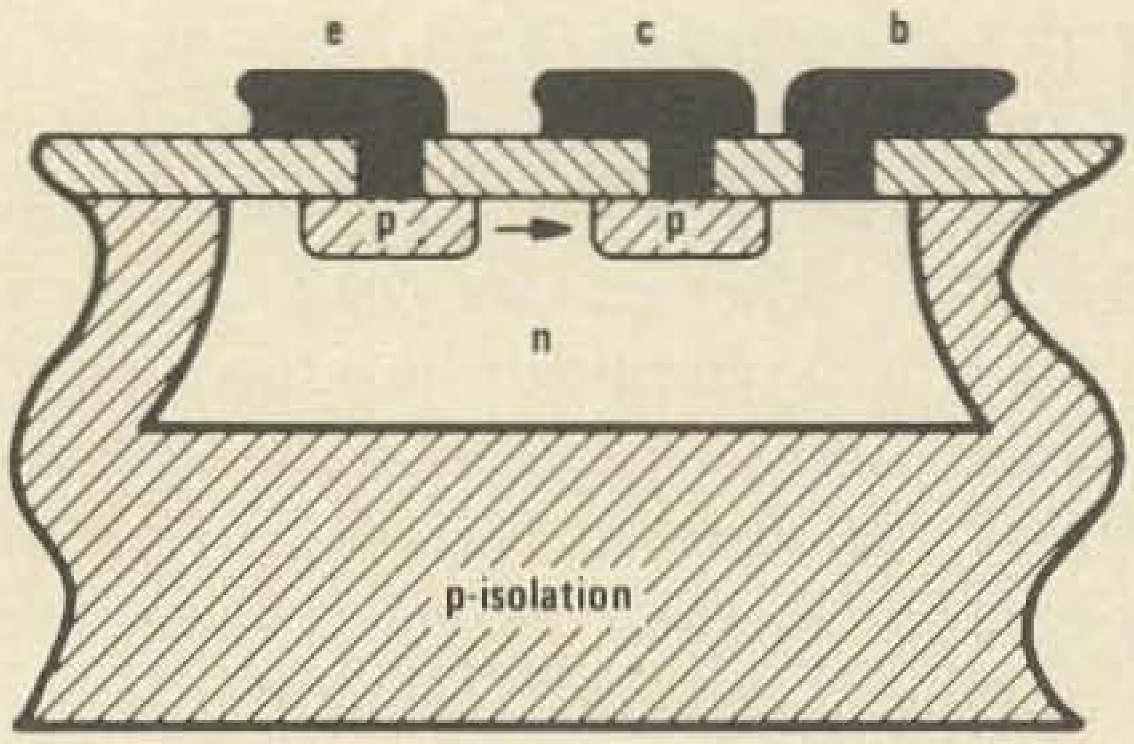


Fig. 4. Lateral PNP (cross section).

What Are the IC's Limitations?

Large Component Tolerances – manufacturers, despite their most careful controls, cannot prevent a wider variation in resistance, transistor beta, etc., than would be allowed in conventional circuits. A 1 kΩ resistor might well be 750 kΩ on units from a given production run, and as high as 1.25 kΩ on the same type of device from a different run. This was considered a problem in the early days of ICs, but designers soon discovered circuit techniques which overcame uncontrolled tolerances. While *value* of monolithic elements varies from run to run, the *ratio* of adjacent components is very accurately controlled. For this reason, most ICs are designed to rely mainly on ratios, rather than component values.

Limited Types of Components – Since the basis for the IC process is the same as that used for NPN silicon transistors, we might expect NPNs to be the best components resulting from that process. Adding resistors, diodes (which are really transistor base–emitter junctions), and zener diodes (which are reverse-biased base–emitter junctions), there is a much more limited selection of practical components available to the IC designer than with conventional circuits. Capacitors of any reasonable value take up too much chip space, which increases the IC's cost. A 0.01 μF capacitor, made either by using the capacitance of a large, reverse-biased PN junction, or by using the "glass" layer as a dielectric, with a metalized top plate would be several times larger than the largest ICs commercially made today. Thus, when a capacitor is needed for an IC, it must be placed external to the IC itself. In an attempt to minimize the number of external capacitors, many new ICs depart from the usual RC-coupled interstages, and are instead completely direct-coupled.

Similarly, inductance on a chip is impractical, so that ICs designed for tuned amplification generally require external tuned circuits.

While PNP transistors are used, they are not capable of nearly as good performance as NPNs, since the chemical processing is not optimized for them. Two types of PNP are available: the *lateral* PNP (Fig. 4) and the *substrate* PNP (Fig. 5). The lateral PNP

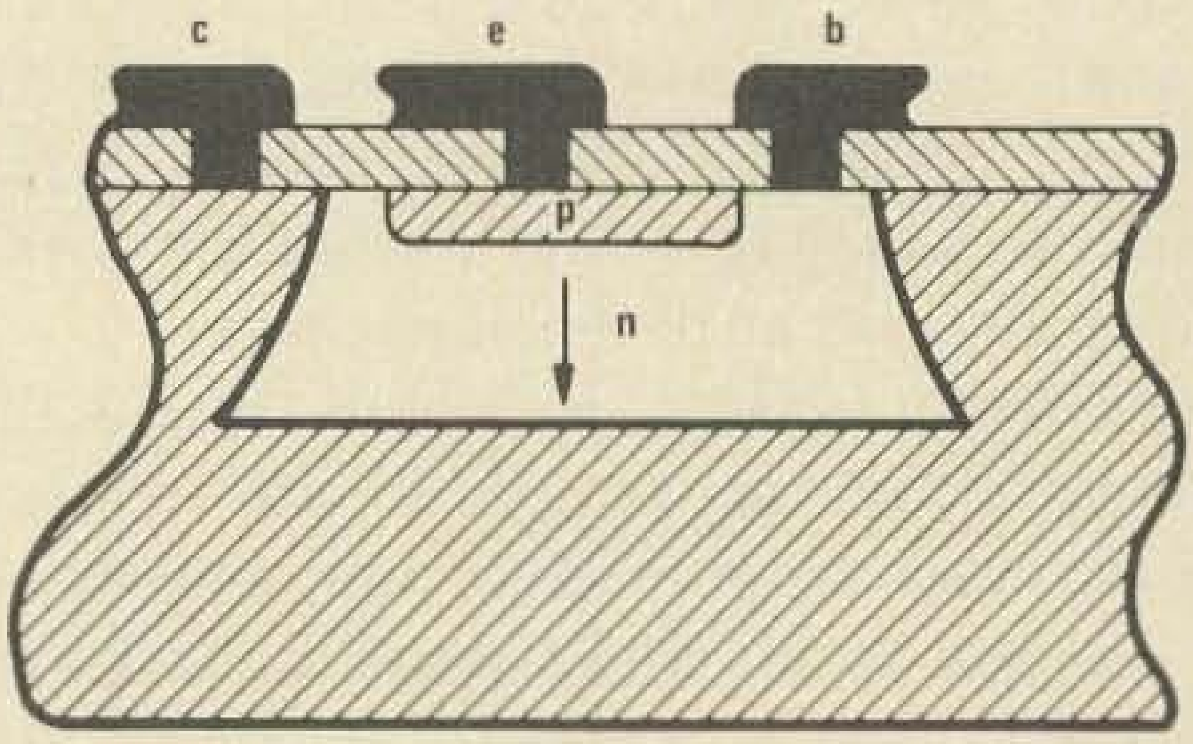
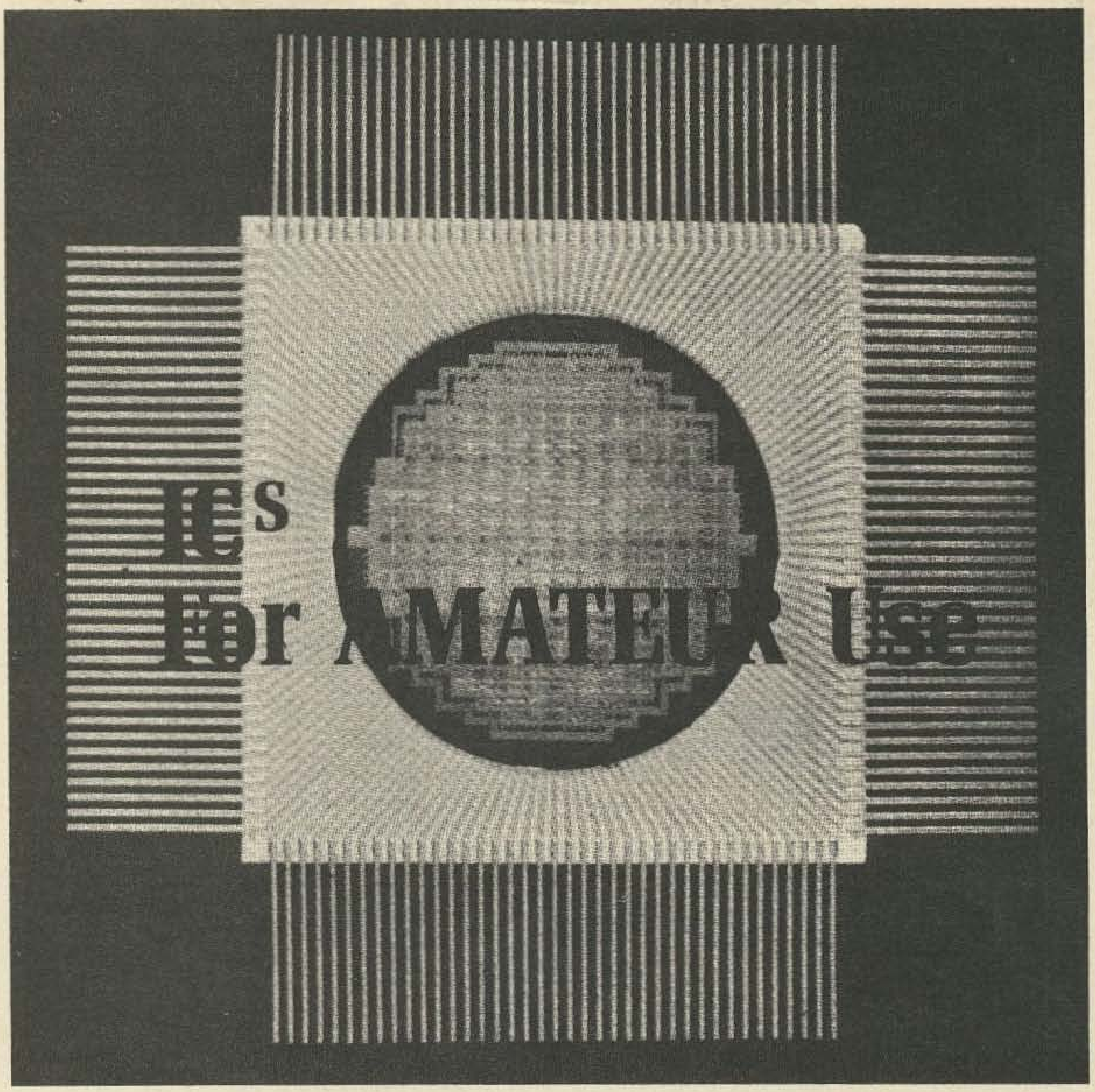


Fig. 5. Substrate PNP (cross section).



ICs For AMATEUR Use

Bill Hoisington K1CLL
Far Over Farm
Peterborough, N.H.

You may not like parts of this article, but then a lot of real life isn't all that likable either. I'm just going to put down my viewpoint of ICs as related to amateur use at the present time as I find them. Some can be very useful, and some are not so useful, even though they work well for their original purpose.

I hope this article will help you decide which kind to experiment with, and how to tell the useful ones from the kind that are good for computers only.

Integrated circuits are simply very small transistors, diodes, and resistors, constructed on tiny dice, sometimes called chips, of substrate material.

Capacitors and inductors are not generally included in these devices; therefore, in communications systems the external components are often many times larger than the IC itself. The benefits of ICs can be considerable, however, as in an example such as the HEP 590, which has high gain, low internal feedback, and absence of detuning effect over the entire avc range.

Computer ICs

This is where the whole thing started, and it was a fascinating story, for the science of electronics at least. In a computer there is a tremendous need for hundreds, thousands, and millions of memory cells, switches, gates, adders, shift registers, "scratch" pads, inverters, counter–dividers, delay lines, digital-to-analog converters, analog-to-digital converters, flip-flops, buffers, comparators, parity generators, current drivers, differential and operational amplifiers, binary decoders, and a host of other device types – all of which are geared not for the ham but for the computer specialist.

In spite of the cumbersome logic that early Scientific American articles declared to be about ready to topple from sheer unreality, some computers *can* do things that cannot be done by men, such as computing an astronaut's course correction in a few seconds, solving vast and complex urgent equations also in seconds, etc.

But what concerns us as amateur–experimenters building new amateur communications equipment is the IC itself. Today's computers use, as one example, a 14-pin flatpack about ¼ in. long by about 1/8 in. wide, and *very* thin. The particular one I have in mind contains some 32 transistors and is the great-grandchild of a two-transisor flip-flop multivibrator, which can "stand on one leg or the other but not on both." To make the pesky little thing foolproof, they included a variety of "constant-current transistors, lockup prevention transistors, phase reversers, (which reverse the "truth table"), and heaven knows what else.

I did detail all the functions in there at one time, a few years ago, and believe it or not the specs on this thing do include a truth table. They do work, even though there is not one capacitor in there. Everything is direct-coupled. With 5V at several hundred amps total on a computer power supply they're happy with 1V in the off state and 4.5V in the on. They work fast, too, like being clocked (pulse driven) by 2,10, or 20 MHz oscillators, or even higher as each year goes by. Yes, this does mean exactly what you're wondering about 2,10, or 20 *million* pulses, or "clicks of the clock" per second.

So the computer can work fast – so fast even that they're now worrying about the time it takes for a signal to travel over printed ribbon connectors from one tray to another. Sound familiar? Like short leads at VHF and UHF?

MSI and LSI

Just another word to let you know that the big manufacturers are not content with just 30 transistors in an IC. No siree!

Medium-scale integration, or MSI, which is just a way station, puts a lot more than 30 devices – really invisible to the human eye now – in that little can.

Large-scale integration (LSI) really gets to be high-density. I have one with 156 leads and 774 announced functions on a single chip.

There are manufacturers who make ICs that amateurs can use, as well as some transistors for TV front ends that look great for VHF and UHF.

Adding another transistor to the design of a chip is a matter of around 3¢ or 4¢, maybe even less today. You draw up a set of masks and reduce them down photographically to where each individual transistor-to-be cannot be seen at all except with a good microscope.

Then these masks are used one after the other to diffuse various materials going onto the chip, such as properly doped silicon, aluminum, gold, etc. – and eventually you have a wafer with fifty or a hundred, or some other larger number of ICs on it. One transistor more or less is thus only a matter of dividing the time involved in drawing it once – plus the engineering time of thinking about how to do it, and how to test it afterwards. This is one of the main reasons for the seemingly large numbers of active devices in some ICs. If there's any possible advantage, in they go! Why not?

Communication ICs

Here is a different story right away. Practically every "radio set" for communication work that I've ever seen or heard of has coils in it (or at least resonators if you go to UHF and microwaves). Now in a little flatpack only a few mils high how are you going to put in any tuned circuits? The answer is, of course, you don't. They go outside. So now where are you? You're up against a conflicting set of requirements.

There are some "natural" divisions of rf, af, and i-f circuitry where attention must be paid to the proximity of the components, as illustrated in Fig. 1. Shielding, or great care, or both, should be used at these points. They are;

1. Rf amplifier input–output.

2. I-f input–output, in particular from the diode region back to the front end –

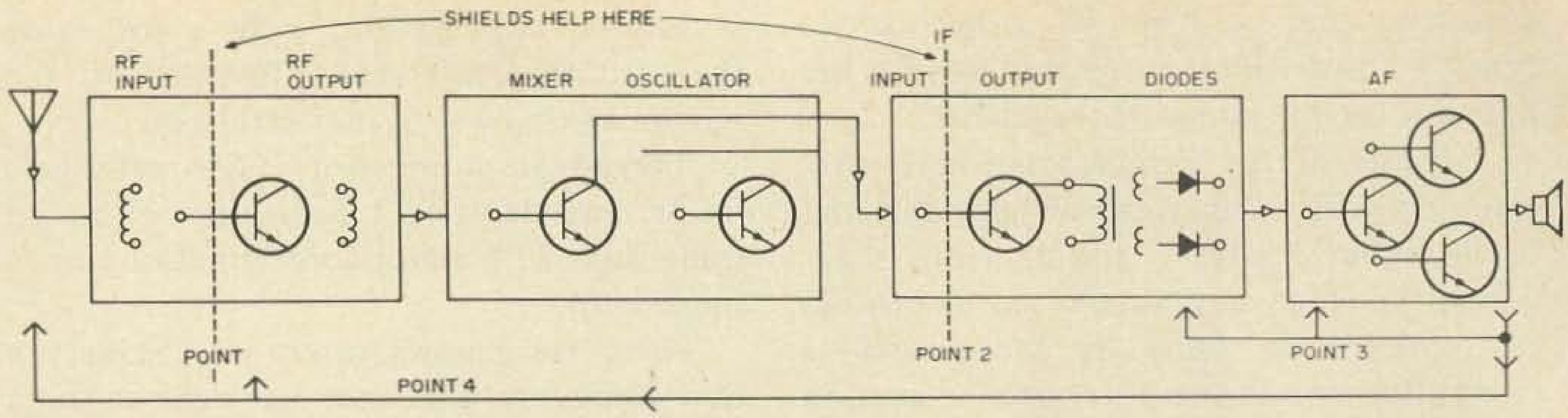


Fig. 1. Block diagram of typical receiver showing "trouble spots."

particularly touchy on certain i-f harmonics.

3. Af input–output.

4. Overall feedback from the af output to the front end, even speaker to antenna, this being often just a loopstick and close by.

In the following rf–i-f IC example you will see that certain things *can* be done on those tiny chips which are very interesting – not only for i-f work but for rf also.

Motorola's HEP 590

Motorola has a very interesting IC device for high frequency amplification, the HEP 590. Two outstanding advantages can be noted: low internal feedback, even when using the maximum gain of over 30 dB, and large avc action without detuning of the circuits

It is packaged in a 10-pin can some 5/16 in. in diameter. The leads can be soldered or inserted in a socket. The present suggested net price is $3.99, which is quite low considering what it accomplishes.

How the HEP 590 Works

Figure 2 shows the internal schematic. When avc voltage is applied to the base of Q2, Q3 is turned off and the ac gain will be at a minimum. This action takes place *without* noticeable change in the operating point of Q1, whose input impedance remains constant, with very little detuning effect on the input tuned circuit even with maximum avc voltage on Q2.

The configuration of Q1 and Q3 reduces the internal feedback to a low figure, which is generally immeasurable up to several hundred megahertz. With the 30 dB of gain obtainable at 60 MHz, this is a great advantage.

Diode D1 is for dc biasing of Q1, under conditions of varying temperature. Being laid out on the same silicon die as Q1, their currents will be closely similar, even with severe changes in temperature, with consequent dc stability.

The noise figure of a two-transistor pair is lowest when the input device uses the common-emitter connection. The second device will then have little effect on the noise figure.

The actual measured gain at 60 MHz is over 30 dB in suitable circuits, which consist of no more than tuned and impedance-matched inductors.

By the use of two of these devices in cascade, bandwidths of over 10 MHz may be obtained at 60 MHz, which shows considerable possibility for amateur microwave amplifier service.

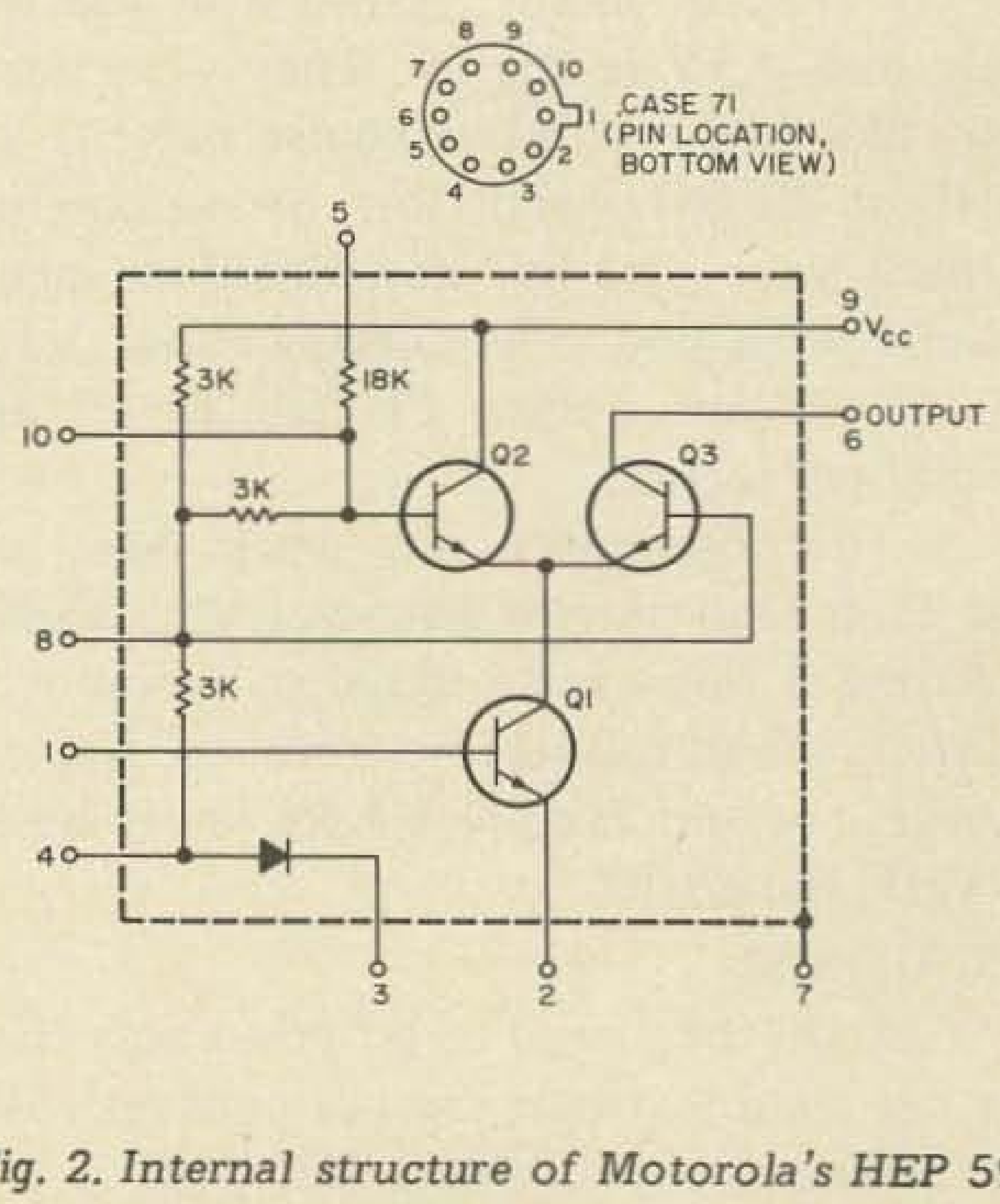


Fig. 2. Internal structure of Motorola's HEP 590 and pin identification data.

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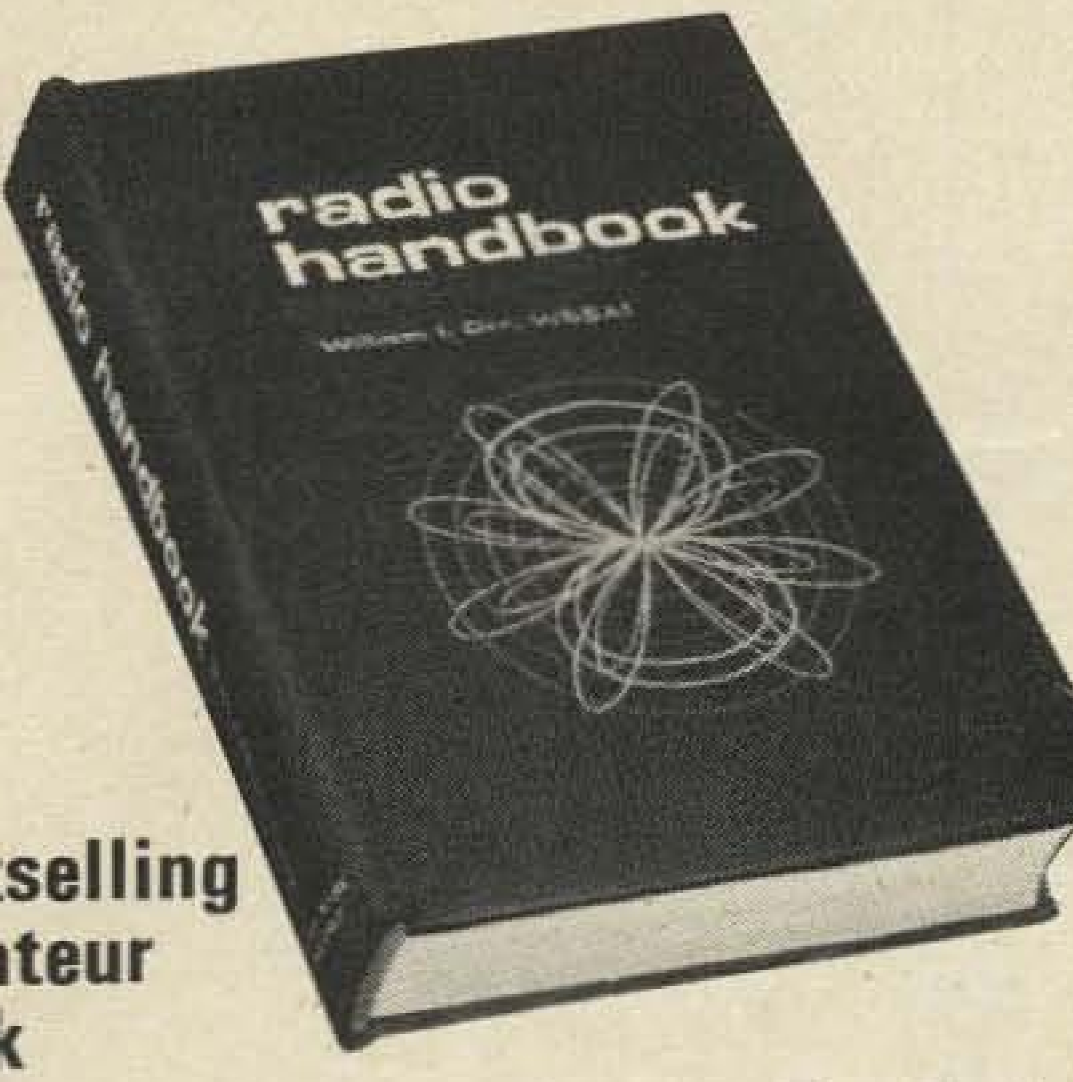

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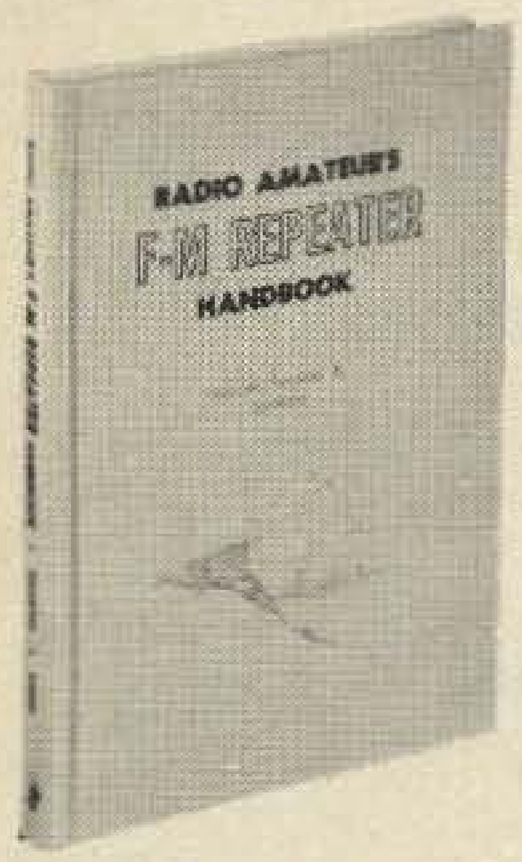

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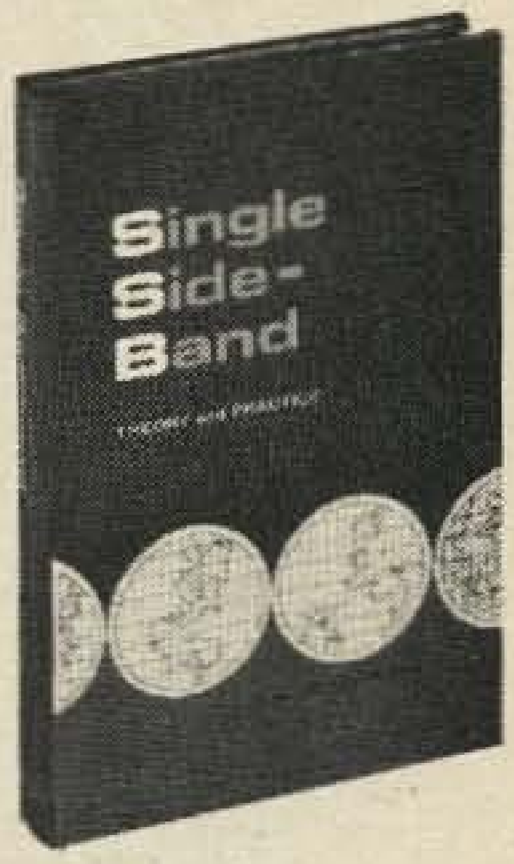

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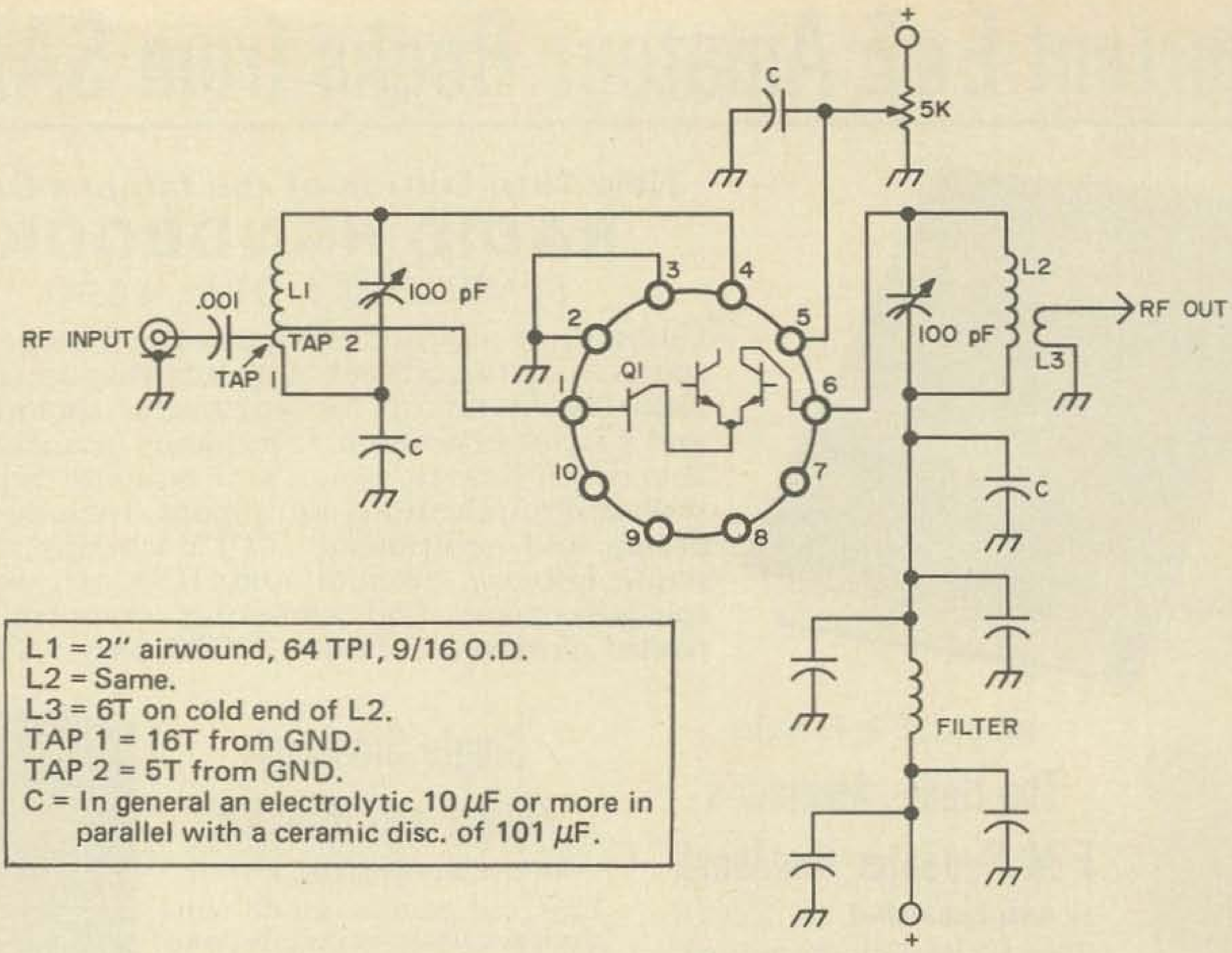

Fig. 3. 40m amplifier built around a HEP 590.

The HEP 590 on the Breadboard

The 40 meter amplifier circuit of Fig. 3 was set up on a copper-clad baseboard with soldered connections to terminal strips. The antenna was brought in to a connection on L1 at 16 turns from the cold end and the 590 input lead (pin 1) tapped at 5 turns. The 100 pF capacitors (C1 and C2) are too large for in-band operating units but are all right for experimental use.

Manual control of the gain was accomplished with the 5 kΩ pot, avc tests to be done later in i-f service.

The output of the device (pin 6) was connected to the top of L2, and 6 turns of small wire wound around the cold end.

I started out with loose-coupled antenna, base input, and output link, but soon discovered this is *not* the way to go with the 590. It likes *lots* of coupling, on both input and output. When this was done, the really large gain of the device became evident. Various signals from 80 to below 40 meters sounded like reception with a superhet receiver (except for the selectivity).

When I used the device as an rf amplifier in front of my lab receiver, I had to reduce the gain of that receiver by a large amount. That HEP 590 really has a lot of sock.

Putting the HEP 590 on 6 Meters

After removing the 40 meter coil and putting in the required values for 6 meters, signals came in right away. Plenty of

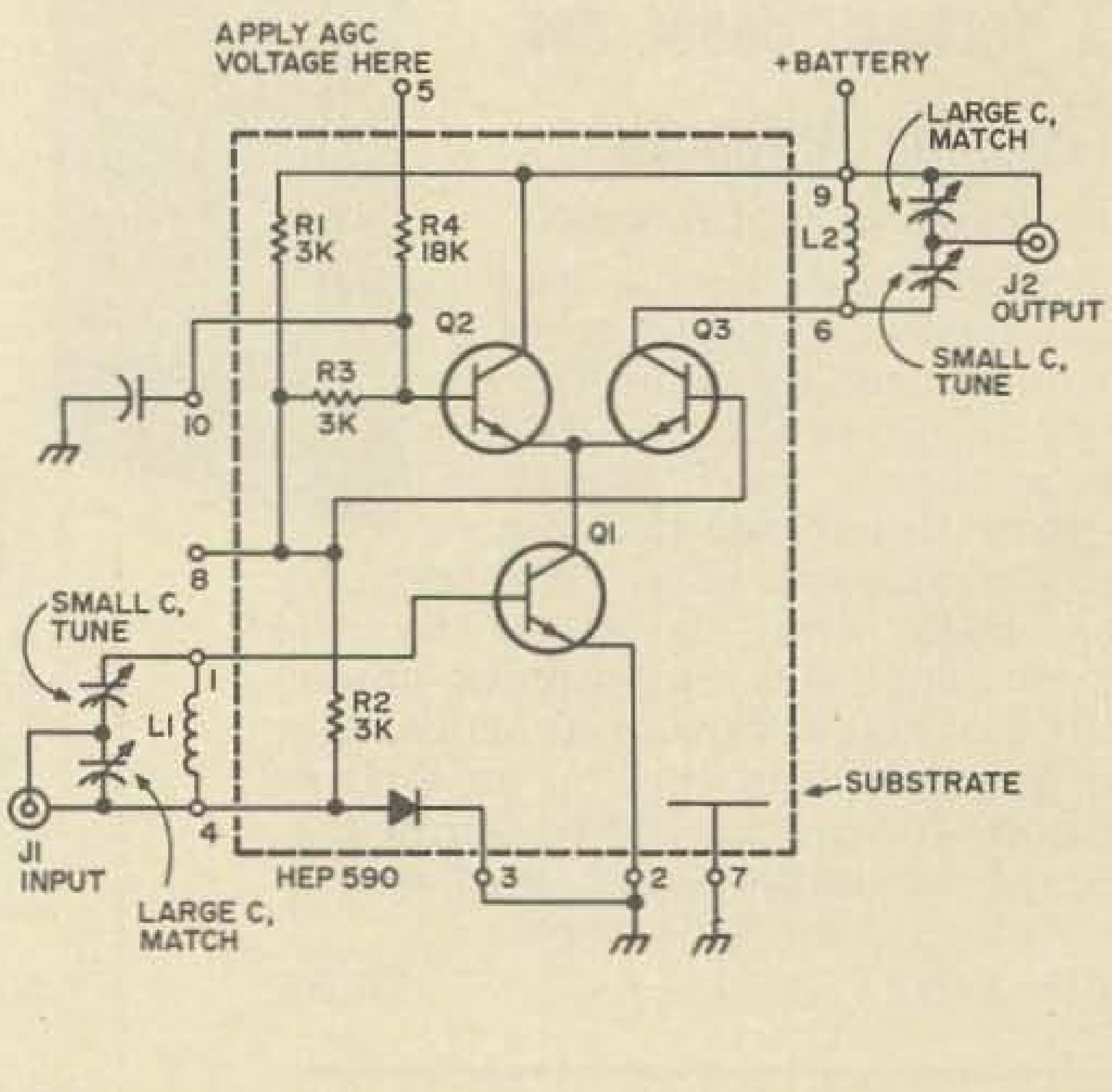

Fig. 4. 6M amplifier built around HEP 590.

stations were heard, and in particular, using a 100 ft wire, Q5 signals were heard that could not even be found on the dial without the 590 preamp. It works! The 6m values for the inductors are as follows: L1 – 4 turns at 8 turns per inch, 9/16 in. diameter; L2 – 5 turns at 4 per inch, 9/16 in. diameter L3 – 4 turns, wound on L2. Figure 4 shows the 6 meter version of the HEP 590 amplifier.

So the Motorola HEP 590 IC linear amplifier works as claimed. It is a relatively easy IC to practice on, with only three active devices inside, and can be built up into a circuit and tested in a day's time.

From working with it so far, I can verify that excellent reduced-size, high--frequency i-f amplifiers for amateurs can be made with it.

The Amperex TAA300

The home of Amperex being not too far away in Rhode Island, I visited down there for half a day and was well rewarded with some new VHF transistors that look swell, and also in meeting some topnotch engineers in the lab.

The TAA300 is a complete af amplifier in one of those little 10-pin cans, and puts out a watt of audio when required – enough to modulate a couple of watts of rf on 6, 2, or 432 – which, along with the exciter section, will take just about all of the dc power of two lantern batteries, rated at 12V and 0.5A.

And it's good for the receiver also. Plug the i-f diode output into it and there's your loudspeaker banging out a watt. Let's take a quick look at one of these.

With ICs, allow for lots of time. Some of this time will be spent in puzzling out three things: the internal circuit, the external circuit, and how to draw one schematic that has both.

I am counting on the TAA-300 to do a lot for use as a 1W af amplifier; but once again, remember that these little gems are not primarily made for experimenters – they're made to be wavesoldered into small radios and TVs by the hundred thousands.

An engineer in a large company can afford to sit down at his desk and spend a week or two figuring how to best put this

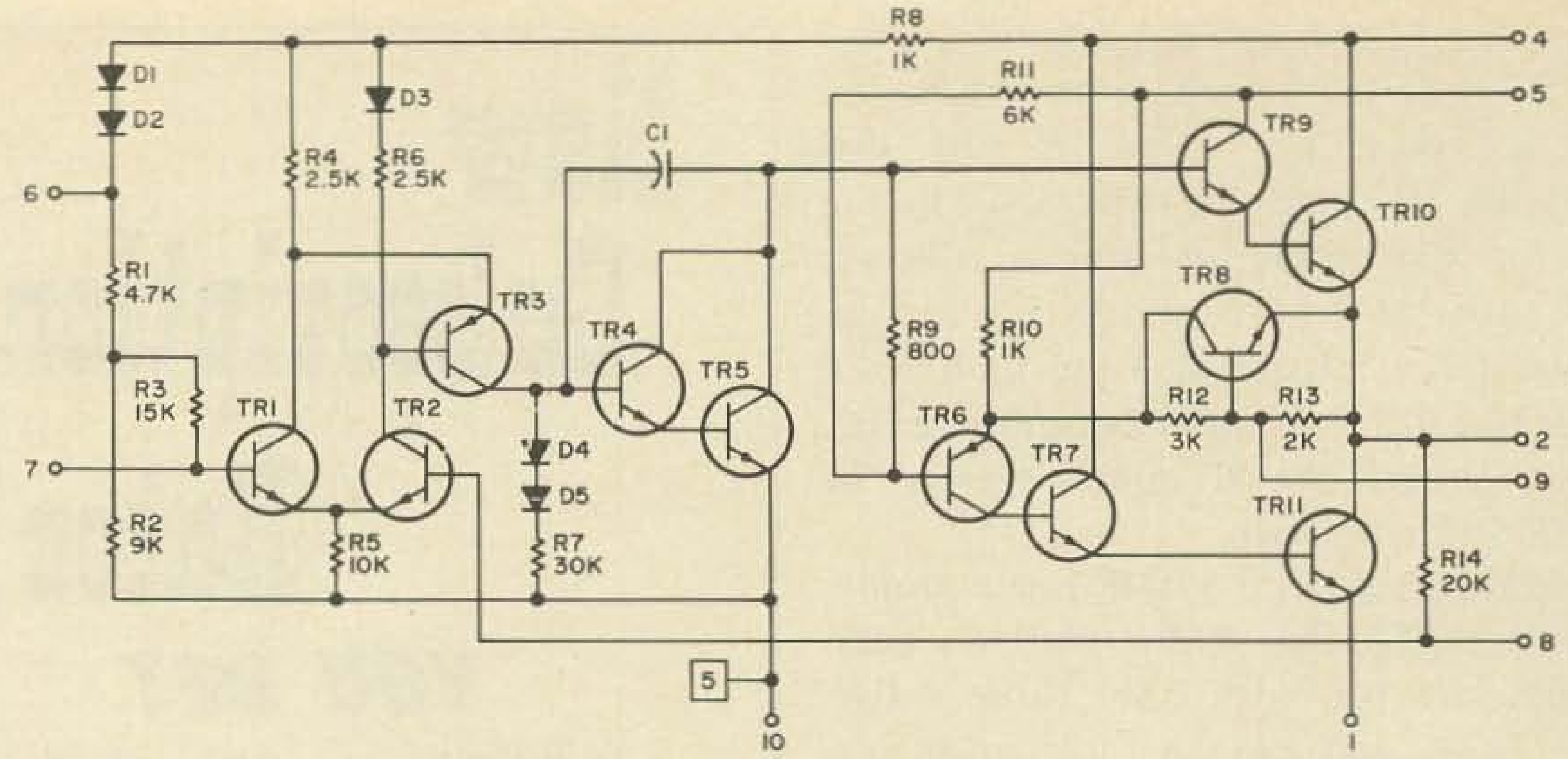

Fig. 5. Amperex TAA300 – a 1W audio amplifier IC.

device into a set because that week can be spread cost-wise over (hopefully) a large number of sets if he does a good job. Can you do this just for one item?

Does the circuit of Fig. 5 look like an audio amplifier? Where's the input and the output? What are those five diodes doing in there? Why 11 transistors just for an af amplifier when the "All-American Five" design will give you mixer, oscillator, i-f, af driver, and af power stage?

Don't think I'm running this thing down, because I intend to use it. I just want you to be prepared for a little "new thinking."

With printed circuitry it has always been my feeling that why should anyone build just one? To learn the printing process involved, yes. For building one circuit, no. Now some of these little 10-pin jobs *are* good for experimenters, and you may also be interested in learning about them for business reasons, too – or for size, although to really cut down in size calls for some pretty expensive external components. Look at Fig. 6, the external circuit. There is a .64 μF capacitor on pin 6, 400 μF from pin 2 to pin 5, a 25 μF capacitor on pin 8, and 47 μF from pin 2 to ground. With "ordinary" size electrolytics three of these values are each four times the size of the device itself, but I expect with voice frequencies some of these can be cut down a bit.

Then there are a few application notes to think about, like the stability question, and a few others, but they are not bad.

All worth-while things take time, and this is one of them. Be advised, and allow yourself time enough to study it out before you pick up that little soldering iron.

Amperex TAD100

Ambitious, knowledgeable, hardworking people have looked at the several-million-per-year market for just plain old radios (new ones, of course) and thought about making ICs for them. And they made some. I have worked with one of them, the Amperex TAD100, and here is the story as I found it.

There are a dozen or so transistors in the little plastic box only 3/4 in. long, as you can see in Fig. 7, the internal circuitry of this one. These transistors are pretty close together in there – much too close for an amateur experimental unit, as you will see.

The manufacturer, ambitious as he was, did produce large numbers of excellent and very tiny receivers with this IC. It has a mixer, oscillator, i-f, detector, and an af amplifier – but no power stages. Almost everything you might need, except you have to add a few things on the outside, of course, as shown in Fig. 8.

There are some good ideas incorporated into this baby – like using two transistors for the mixer. So are three for one i-f stage. I don't particularly go for the four transistors in the af stage, without even the power output unit yet, but it does work.

What doesn't go for the amateur experimenter is the fantastic proximity of the input, the mixer, the oscillator, the i-f and

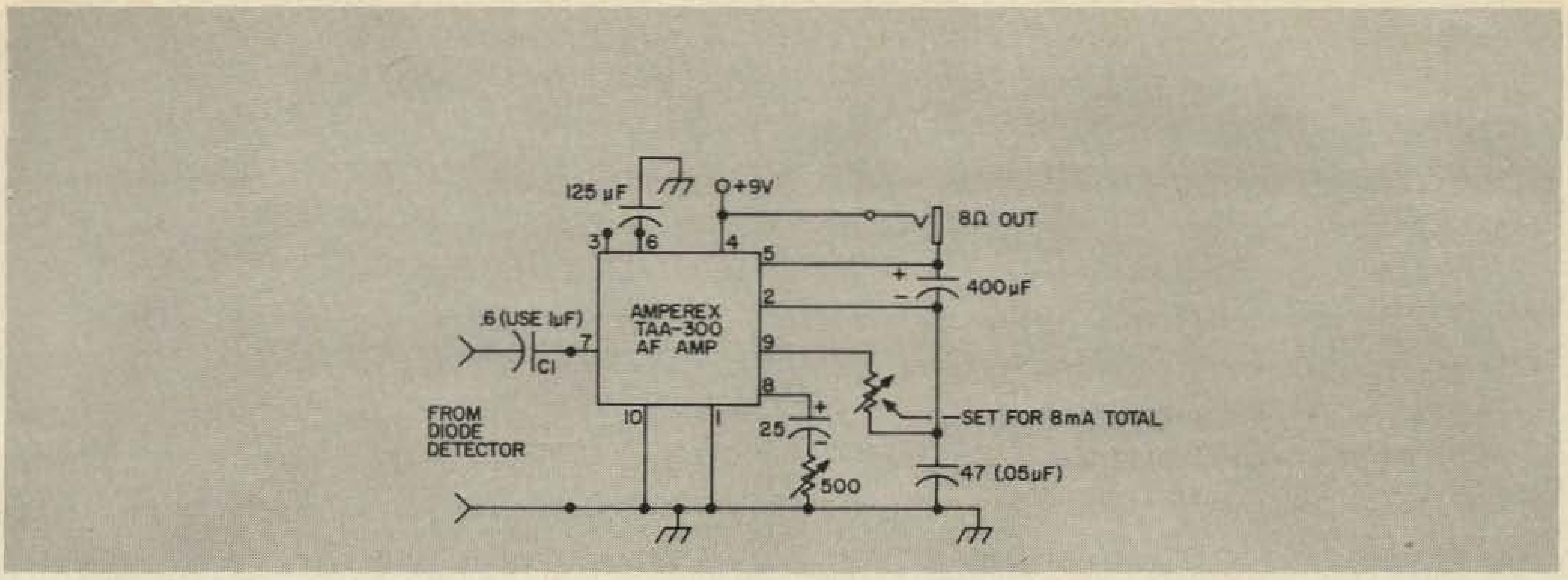

Fig. 6. External connections required to get the TAA300 operating as a complete amplifier.

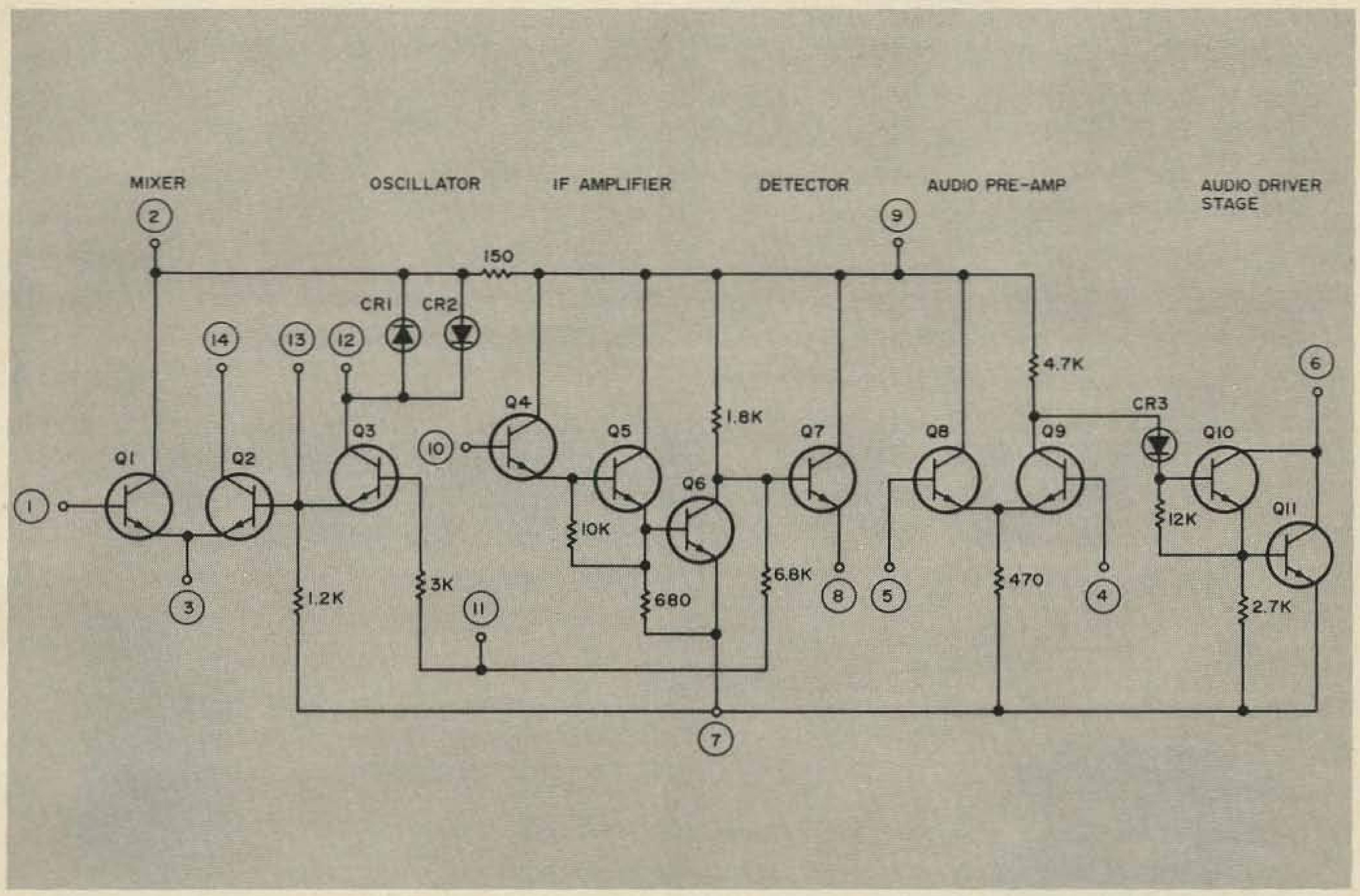

Fig. 7. Amperex TAD100 is a complete broadcast receiver in one tiny package.

the af – all in there together on that one tiny chip. Just too, too close for me. When everything is running right with all the precautions advised and an exact copy of the original printed board is made up and all the components are in exactly proper places, it does work as a BC set.

One of the precautions listed: "The oscillator must be limited to 100 mV; otherwise it will get into the i-f and the af." It did! I worked 10 days on this particular IC and to make a long story short, the mixer and the i-f ran okay at times (and at times not), but when the internal local oscillator was used, I kept running into trouble.

Bear in mind, such an IC does work fine for mass production of BC sets. It's just that for an amateur experimenter as a single unit, there is too much feedback involved. Also, the oscillator is strictly limited to the BC band service, which

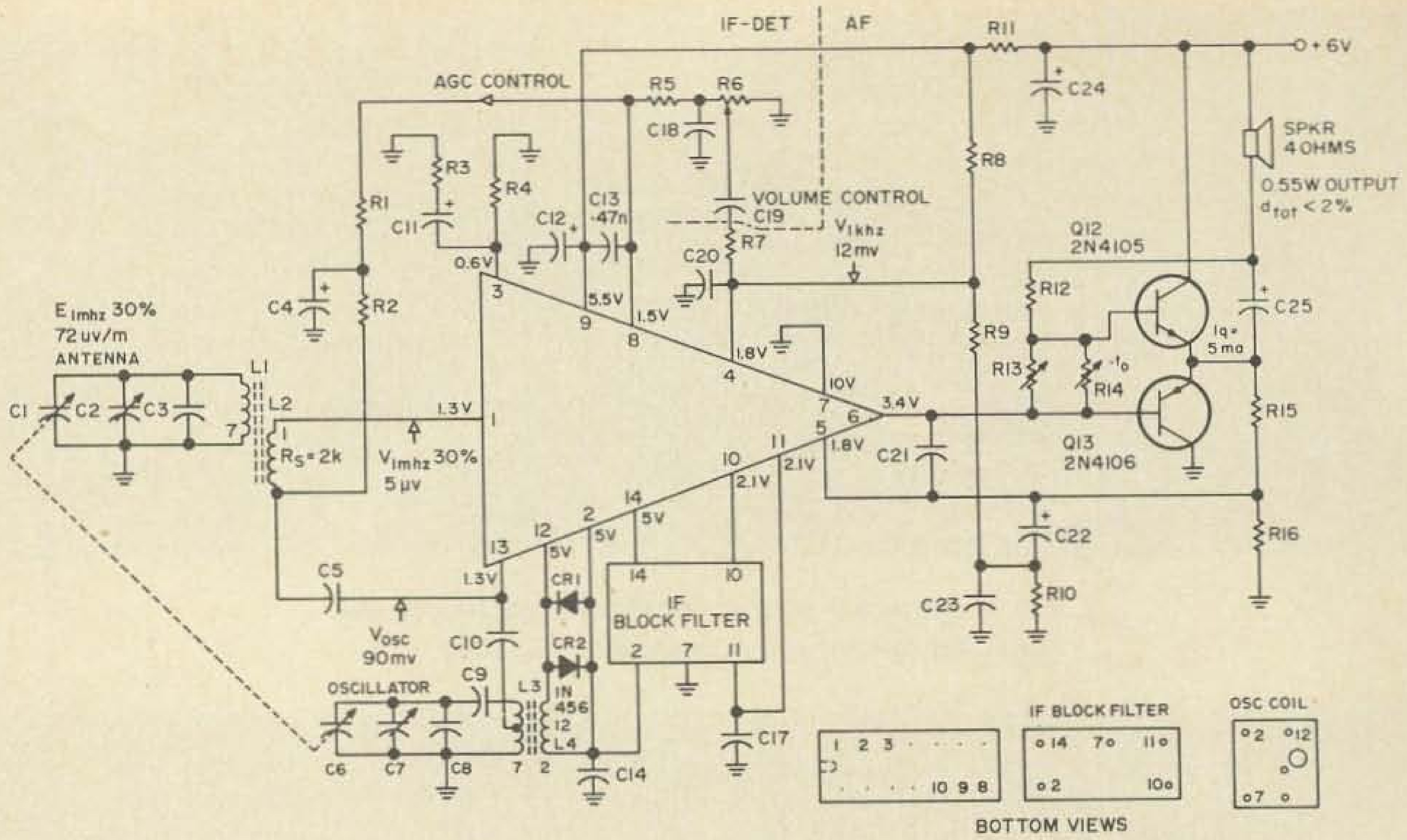

Fig. 8. External circuitry. B.C.–I.C.

precludes using it as an amateur converter. The people handling this unit are excellent engineers and have some other *very* good devices; and they are still working with newer and better devices for a complete set (including an FM job!), so we will almost certainly see them again soon.

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(Cont. from page 10)

is irrelevant. I did notice that most of the fellows that managed to work through to me were interested in a New Hampshire contact or else wanted to just say that they enjoyed the magazine. No traffic for the news pages ever developed.

I'll try and get on around 14.210 or so at 2100 and 0200–0300 whenever I can. If you have news items please just mail them in and let's forget that General section of 20 meters.

News Pages

If you are involved or get word of anything that you think would be of value to the 73 newspages please take it upon yourself to act as a reporter and get the news in to us. The last minute for each month is the 20th.

The news pages not only are of considerable value to our regular readers, but we go to the trouble and expense each month of reprinting the first two pages and sending them to every congressman in Washington. Thus your news stories can do a great deal towards creating a favorable climate for our hobby in Washington.

In addition to the news story having your byline, we will also send you a PRESS pass which can help you get into restricted places for future news stories.

In addition to news which is of national or international interest we also would like to have news of activities on the various amateur bands . . . particularly interesting nets . . . unusual contacts . . . DX stations of note . . . VHF band openings . . . contest announcements . . . special awards . . . etc. These announcements won't warrant a press card and byline, but they will help to make amateur radio more fun for all of us.

Your Vote Counts

Half of the sixteen ARRL directors are up for reelection each year. When those of you who have not dropped out of the League cast your vote this fall you might keep in mind that little is to be gained from keeping the same old faces in office. A reading of the minutes of the last board meeting will tell you the story. . . most of them are sales reps coming to you from headquarters rather than your representatives running your club.

More Phone Bands?

The September issue of QST carries an article on why the ARRL directors decided against expanding the U.S. phone bands. The article is interesting, but completely out of touch with the realities of 1970, expressing the leftover concepts of twenty years ago.

The main theme is that if we expand our phone bands, phone operators in the rest of the world will move into the CW bands to get away from us. Back in the AM days this would have been so. It is unfortunate that so few directors and HQ personnel are active amateurs; otherwise, they would certainly have realized how completely out of date the arguments were.

Few DX contacts are made cross-band these days compared to the old AM days. Twenty years ago it was unusual to work a DX station operating inside the U.S. phone band. Today it is extremely unusual to work one outside our band, with the exception of a few DXpeditioners who have curious reasons of their own for split-frequency operating. There are times when it is better for a rare DX station to work split, but the need for this is unusual. There seems to be little need for a "DX" portion of the band today for phone.

While operating from JY1 I tried operating above and below 14200 and I found vastly more DX activity above 14200 than below. The lack of U.S. phone stations below 14200 has encouraged commercial occupation of these frequencies and few of them are free of this sort of interference, and thus few are of much use to anyone anywhere. If this band were opened to U.S. phones I believe that the periodic assaults of QRM from the U.S. would drive a great many of these interlopers to clearer channels, thus benefiting amateurs everywhere.

It is unfortunate that the ARRL directors are so inactive that they are not aware of conditions as they are in 1970 and thus were talked into completely giving up the weak try they made to get HQ to push for more phone frequencies.

If you think I am exaggerating or coloring this then please take the time to read the Walker article in QST and the board minutes. Ugh.

. . . Wayne ■

PRACTICAL IC REGULATOR CIRCUITS FOR HAMS

Don Nelson WB2EGZ
9 Green Ridge Road
Ashland NJ 08034

The experimenter has broad horizons with the many low-cost ICs and semiconductors available today. While many of the ICs have been designed for a specific service, such as an audio amplifier or a logic switch, there are types which contain several transistors to be used in almost any application. The RCA CA3018 exemplifies the second category. Let's examine the device as an introduction to integrated circuitry.

Four silicon transistors are formed on a common monolithic substrate within the CA3018. Two of these transistors are interconnected by having the emitter of one tied to the base of the other. Either of these transistors may be used separately since an external lead connects to the emitter-base link. The intent of the interconnection is to use the transistors in a Darlington circuit. The other two transistors are isolated as shown in Fig. 1. Notice the substrate is important enough to have its own lead. In this IC, as in most others, there is diode action between the substrate and some elements of the circuit. You can see this characteristic using an ohmmeter between the collectors and the

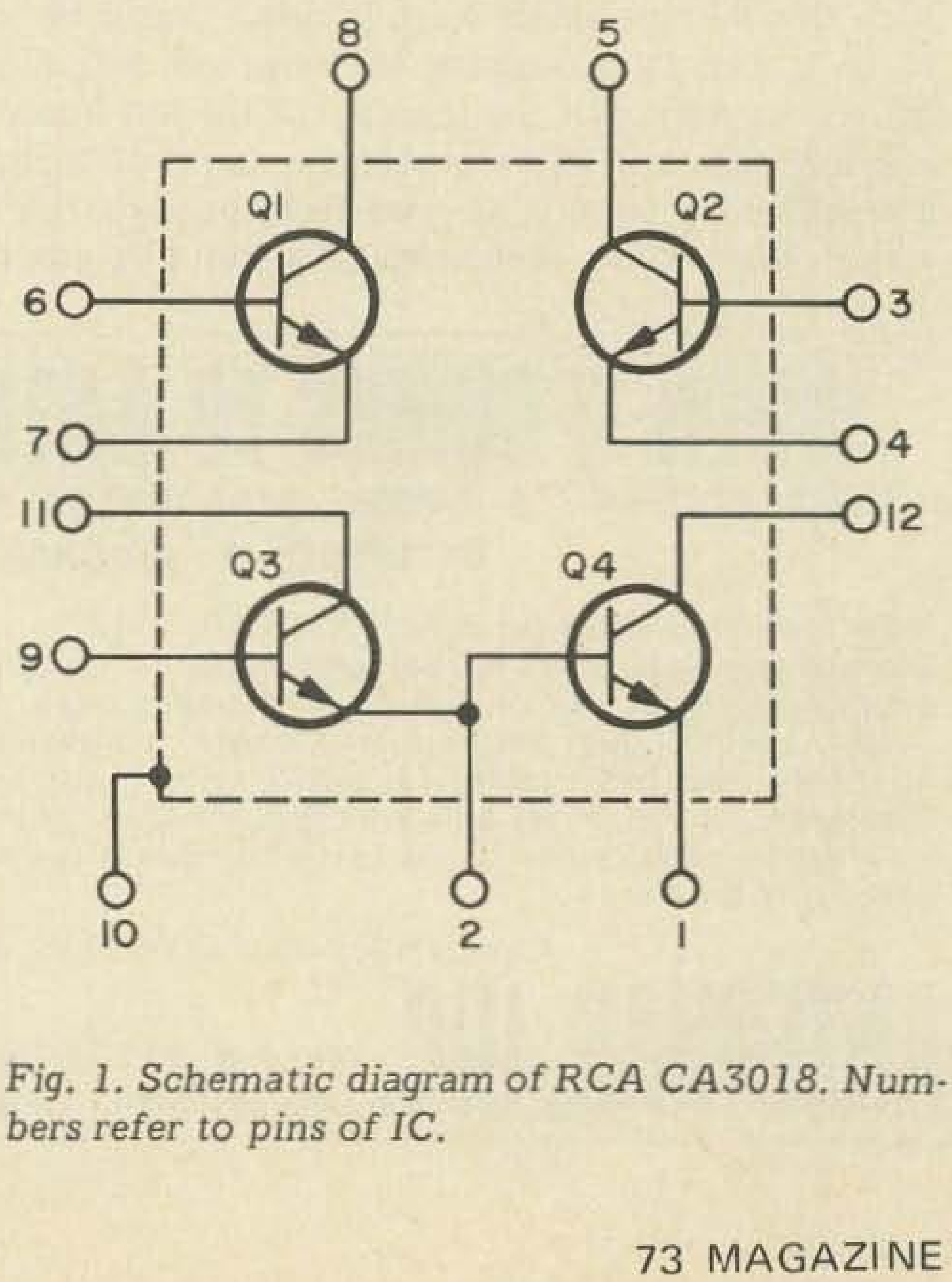

Fig. 1. Schematic diagram of RCA CA3018. Numbers refer to pins of IC.

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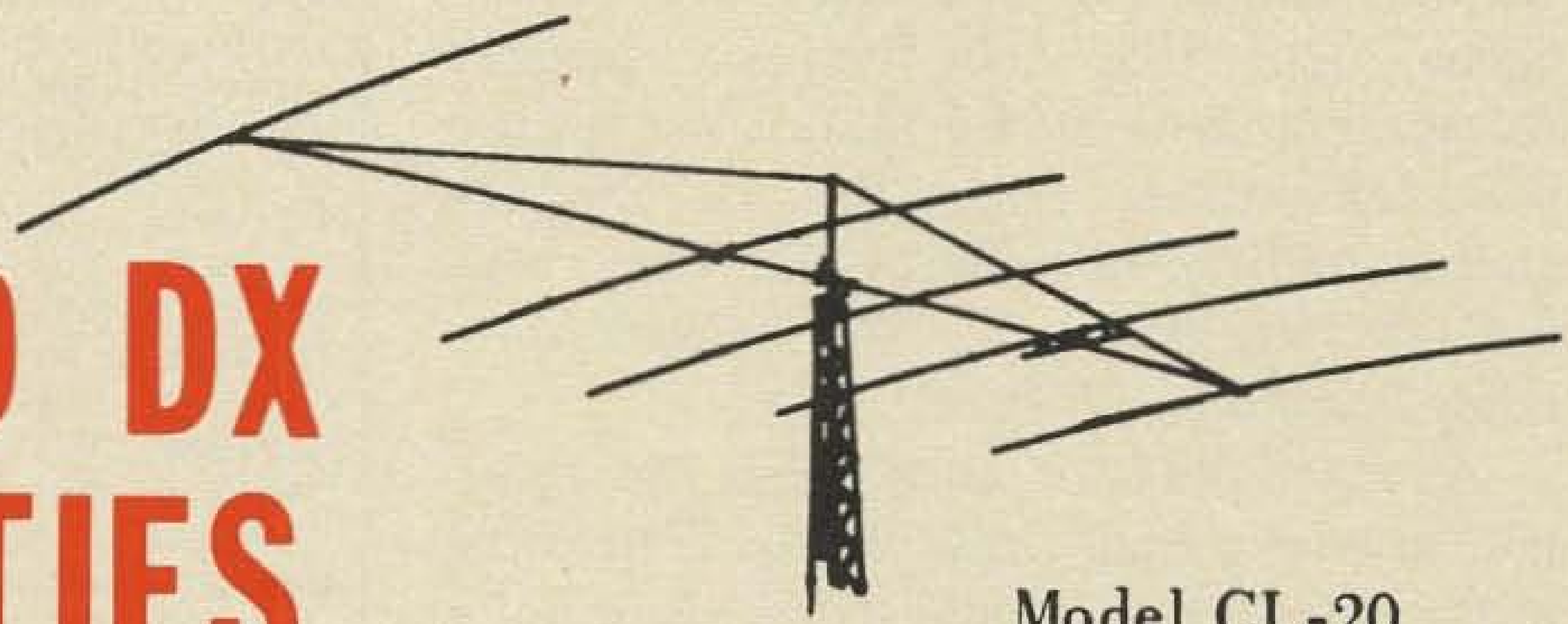

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- MATCHING SYSTEM: Balanced Capacitive.
- FEED POINT IMPEDANCE: 52 ohms.
- NUMBER OF ELEMENTS: 5. Aluminum tubing; 6063-T832.
- MAXIMUM ELEMENT LENGTH: 38 ft. 1½ in.
- BOOM LENGTH: 46 ft.
- RECOMMENDED MAST SIZE: 3 in. OD.
- TURNING RADIUS: 28 ft.
- WIND SURFACE: 18.7 sq. ft.
- WIND LOAD (EIA Std. 80 MPH): 364.45 lbs.
- ASSEMBLED WEIGHT: Approx. 139 lbs.
- SHIPPING WEIGHT: Approx. 145 lbs. via truck.

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Mosley Electronics Inc. 4610 N. LINDBERGH BLVD., BRIDGETON, MO. 63044 substrate. These diodes are reverse-biased by connecting the substrate to the most negative point in the circuit, thus isolating the transistors. If the substrate is not connected in such a fashion, you may not get transistor action from the circuit.

The transistors in the CA3018 are useful from dc to 120 MHz. One of the big advantages of integrated circuitry is the matched characteristics of the transistors within. Gain, for example, is matched better than 10% and the base–emitter voltage match is better than 2 mV over a wide temperature range. Because of these characteristics, this and other integrated circuits are excellent for temperature-compensated circuitry.

Another plus for most ICs is the excellent low-frequency noise figure. Transistors in the CA3018 array boast 3.2 dB of noise at 1 kHz. At 100 MHz, the noise figure is typically 7 dB, so this device is favored for operation below VHF.

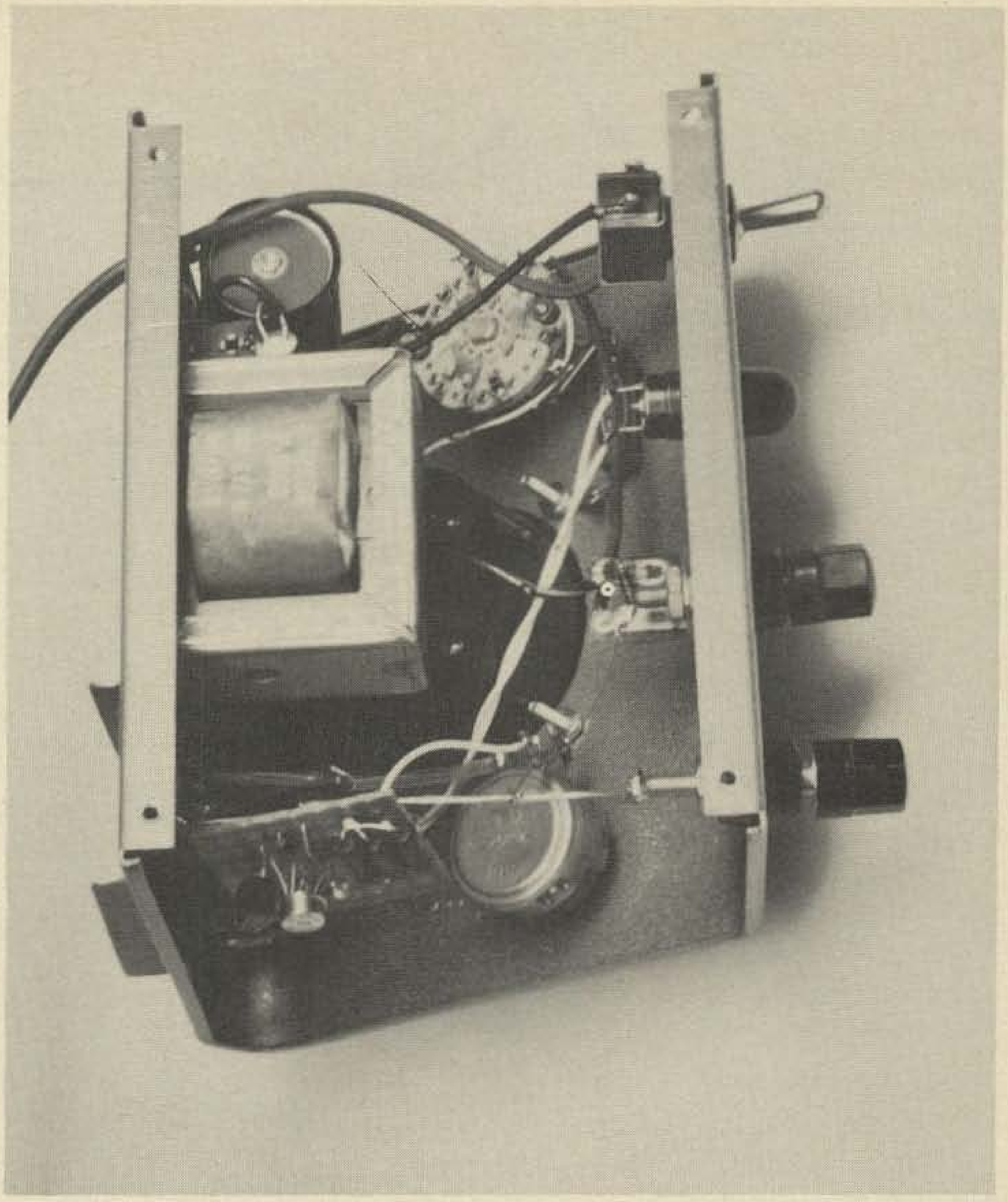
Learning to use the best characteristics of a device and learning to design around its limitations are good engineering practices. I once heard a ham brag, "The 4X150 is a great little tube – mine is dripping solder from the radiator, but my power output hasn't dropped." Well, those good old days are gone when you use semiconductors – so learn what the ratings are all about. Maximum and minimum values for the CA3018, which must be observed, are listed in Table I.

Table I. IC Parametric Limitations at 77°F.

Parameter	CA3018	CA3018A
Maximum power dissipation:		
any single transistor	300 mW	300 mW
total package	450 mW	450 mW
Derate 5 mW/°C for TA >85°C		
Maximum collector-to-emitter voltage	15V	15V
Maximum collector-to-base voltage	20V	30V
Maximum collector-to-substrate voltage	20V	40V
Maximum emitter-to-base voltage	5V	5V
Maximum collector current	50 mA	50 mA

Those readers who are familiar with transistors will find only two new ratings; a total-package power rating, and a collector-to-substrate voltage rating. The first is a limit for the sum of the power dissipation of the individual transistors. For example, if one transistor operates at the 300 mW level, the average power of the remaining

Exterior view of the 500 mA power supply. The case used is a Bud CMA 1930.



Placement of parts is only critical with respect to squeezing everything into the box. The 2N5295 transistor is outside the rear apron and insulated from the main chassis. A piece of copper 2-1/2 x 2 x 1/32 in. forms a heatsink for the power transistor.

three may not exceed 50 mW each (300 + 3 x 50 = 450). The second new rating refers to the breakdown voltage of the collector-to-substrate diodes. These diodes are always reverse-biased because the substrate has been connected to the most negative part of the circuit. It is easy to determine the exact voltage in a circuit because the collectors are frequently at the most positive voltage.

Many ICs have low breakdown voltage ratings, which can be a serious disadvantage. In some cases, you may be able to design around the problem. Another problem at the experimenter's level is the fact that if one transistor is destroyed, the whole IC has to be replaced. This disadvantage is somewhat offset by the low $1.62 cost of the CA3018, but it is hard to rationalize soldering 24 leads for each mishap. A discrete transistor could be used in a crisis with the CA3018. Better yet, use a socket for breadboarding.

Applications

The CA3018 is a natural choice for a power supply regulator amplifier. Such an application, I feel, is also interesting for analysis. In Fig. 2, I have drawn a very basic regulated power supply using three of the transistors. Let's examine its characteristics from the ratings of the IC.

Nearly all the current to a load will flow through Q4 (pins 12 and 1); therefore, we are limited to 50 mA, which is the maximum collector current of any single transistor. If you think about it, this is all the current required by many circuits. The power supply could service almost any circuit now operated on small 9V batteries. An FM portable receiver draws peaks of less than 20 mA; AM radios draw even less.

The second rating to consider is the collector-to-emitter voltage. The greatest permissible value is 10.5V, which is well under the 15V rating of the transistor. The collector–base breakdown voltage is not

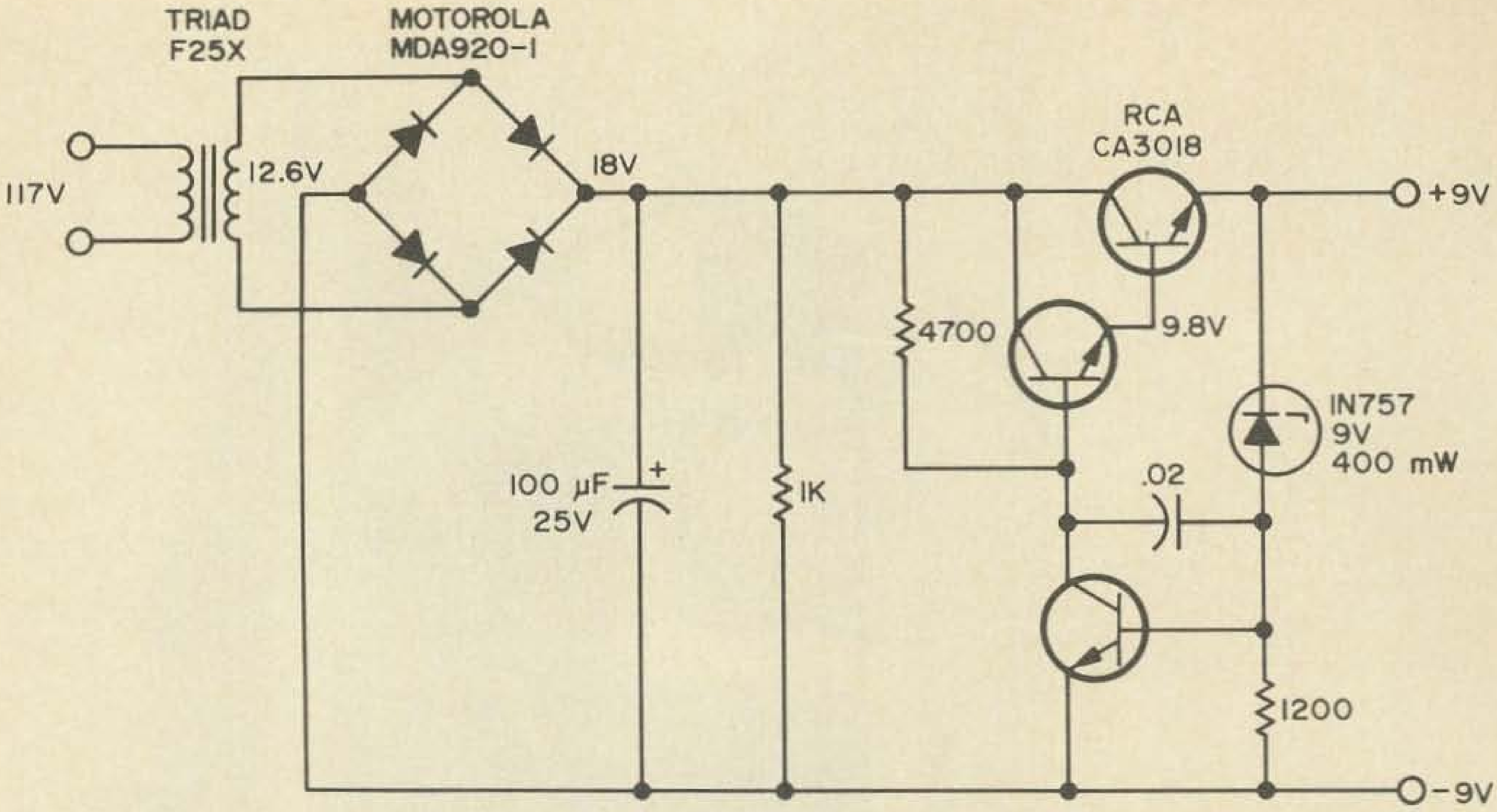


Fig. 2. Regulated 9V 30 mA power supply using CA3018.

exceeded and the emitter–base junction is never reversed-biased, so the design is clean in those respects. Don't forget the collector-to-substrate rating. In this case, the maximum voltage seen is 18V: okay for this circuit, but not for the next one.

When considering the power rating, it is safe to assume we will not exceed 85°C (no derating necessary), and the power dissipation of Q4 will be much greater than the total power of Q1 and Q3. At 50 mA of current, the power (P=IE) would be .050 (18–9)=0.450W, which is high for a single transistor. A reduction in output current or lowering the input voltage on pin 12 is necessary to operate within ratings. In any case, it would be wise to heatsink the IC for this circuit. You may expect it to get hot above 30 mA.

The shortcomings of the CA3018 become apparent as we attempt to design a more versatile supply such as the one in Fig. 3. A 2N5295 power transistor was added to the basic circuitry in order to

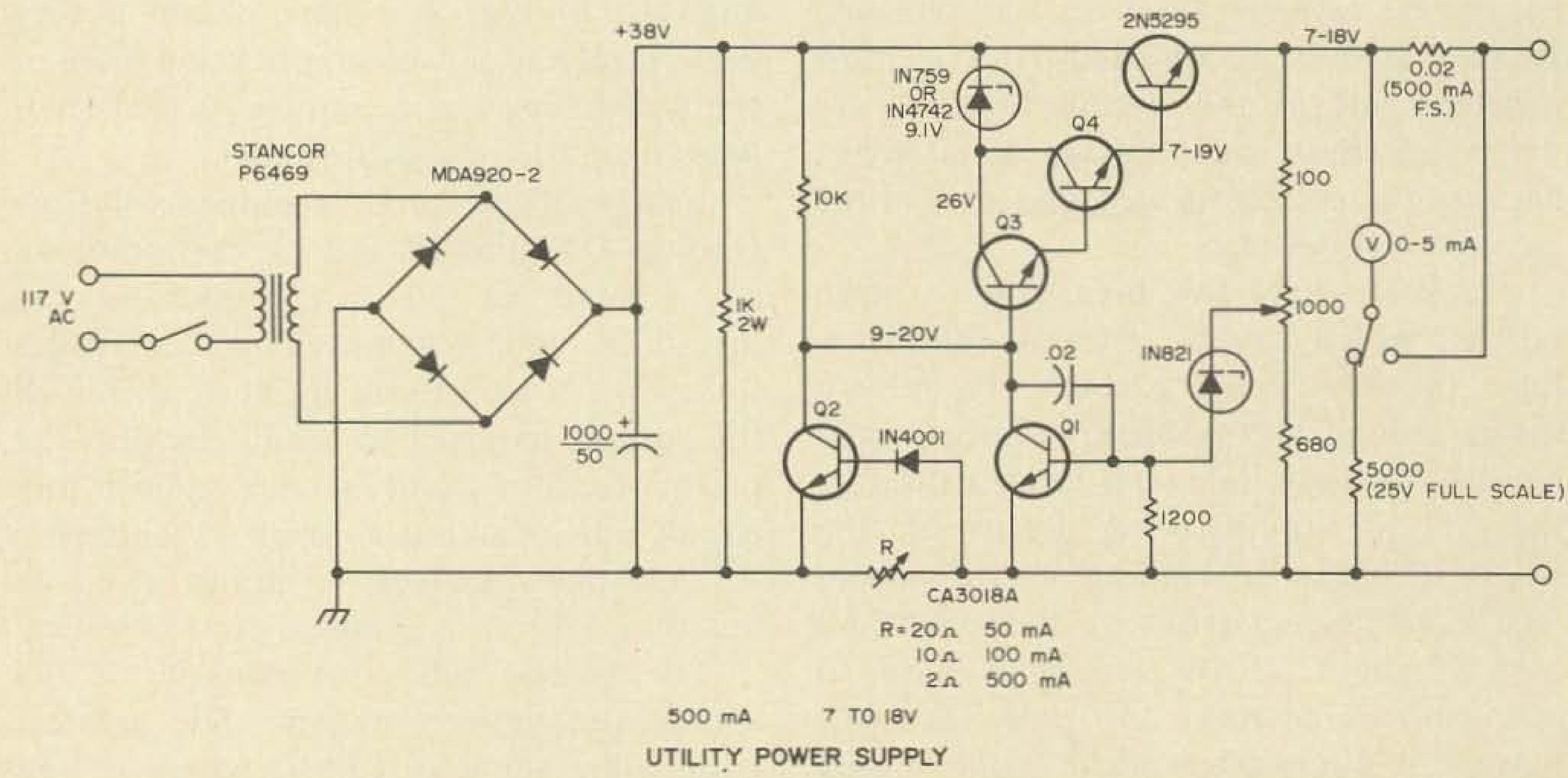


Fig. 3. "Utility" power supply with 7–18V output. Resistor R determined by current requirements: 20Ω–50 mA; 10Ω–100 mA; 2Ω–500 mA.

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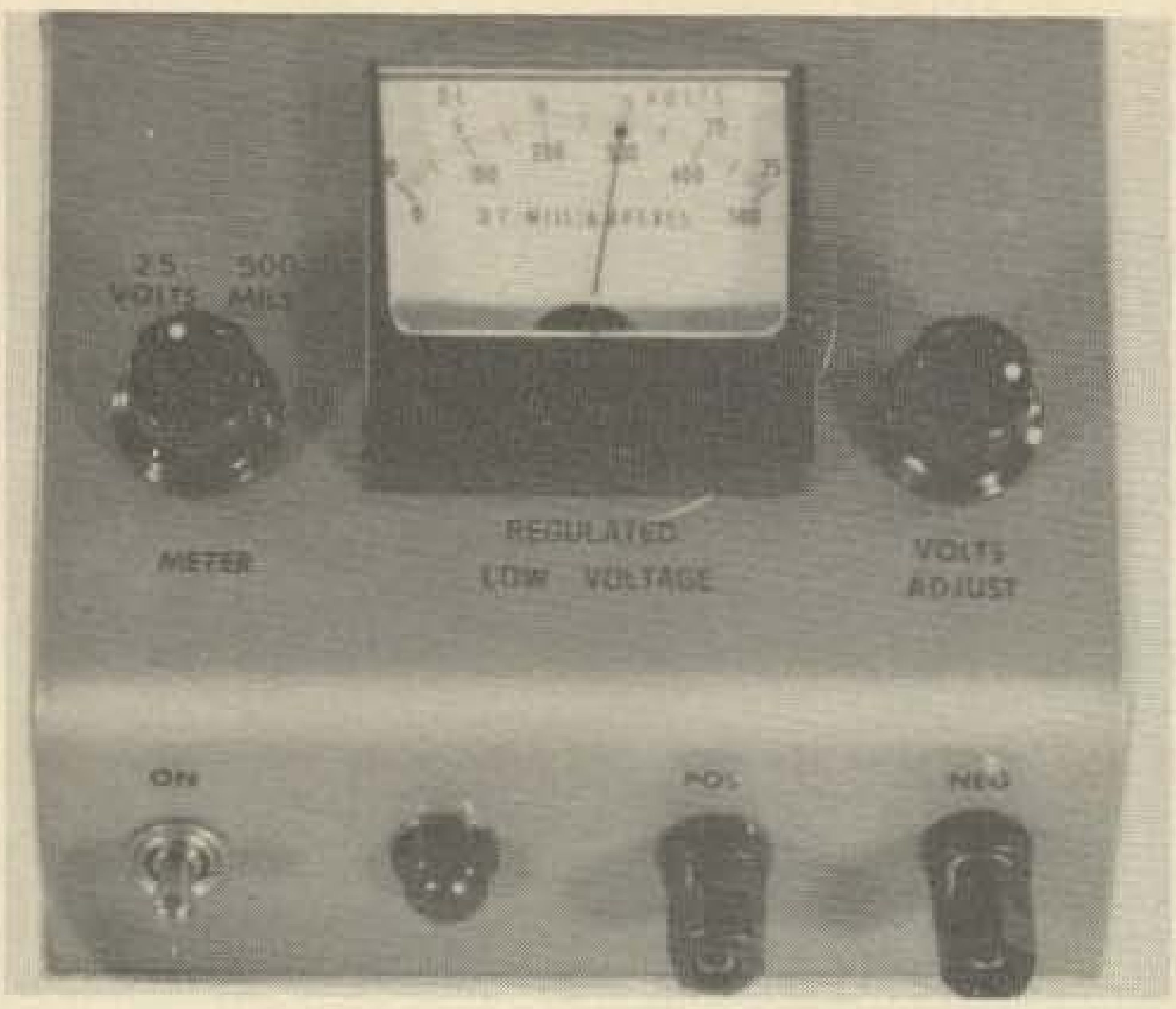


The completed 500 mA regulated low-voltage power supply.

operate to supply to 18V and 500 mA. Other changes include the use of a temperature-compensated zener diode, variable voltage output, and current limiting by use of the fourth transistor on the IC. Incidentally, you might just want to build a power supply like this if you are newly acquainted with semiconductors.

The 2N5295 will handle 500 mA and higher voltage with ease. If we assume the beta of that transistor is 50 at full load, the base drive required would be 500/50, or 10 mA. That is no problem for Q4 of the CA3018. On the other hand, it soon becomes apparent that we need higher than 20V breakkdown. Some relief is obtained by using the CA3018A, but not quite enough to handle the collector–emitter voltage drop across the Darlington pair. By using a zener diode between the high-voltage point and pins 11 and 12 of the IC, the collector-to-emitter voltage requirements are reduced, as is the collector-to-substrate voltage.

It is not necessary to use a temperature-compensated zener here. Collector-to-emitter voltages are the only ones above ratings now. Three CA3018s tested had collector-to-emitter breakdown voltage ratings in excess of 23V; however, this is a weak point in the design.

Power requirements are lower with the addition of the 2N5295. The maximum power through Q4 is 23V x 0.010A= 0.230W, enough less than the maximum rating that no heatsink is necessary.

A word about the operation of the current limiter is in order for any prospective builder. Transistor Q2 is normally turned off until an overload occurs. At this time, the voltage drop across R is enough to turn on the 1N4001 and the emitter–base junction of Q2. As the transistor is turned on, its collector is pulled toward ground, thus turning off Q3, Q4, and the 2N5295. As soon as the overload is removed, the supply recovers to its former voltage. This limiter may be made variable for limiting at lower currents. Approximate limiting values are shown in the schematic. Under extreme current limiting conditions, the collector-to-base voltage of Q3 and Q4 will approach 26V. This is acceptable for the CA3018A.

While the CA3018 is not truly a circuit, it provides an interesting introduction to the technology and characteristics of integrated circuitry. Its versatility invites experimentation. For those who would like to duplicate the regulated power supply shown in the photos, I include a full-size

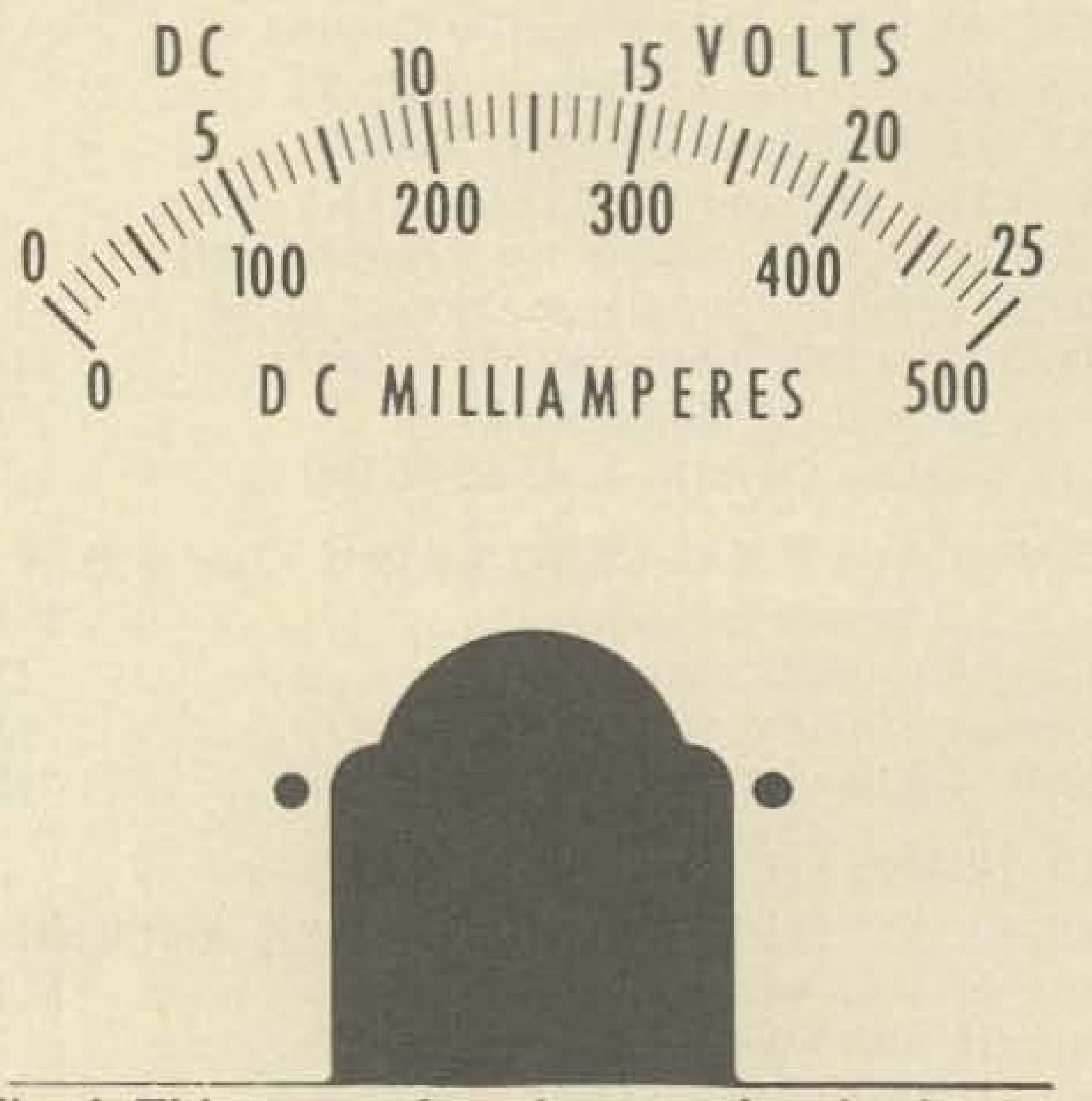


Fig. 4. This meter faceplate can be glued to any appropriate sized meter with a 5 mA full-scale rating.

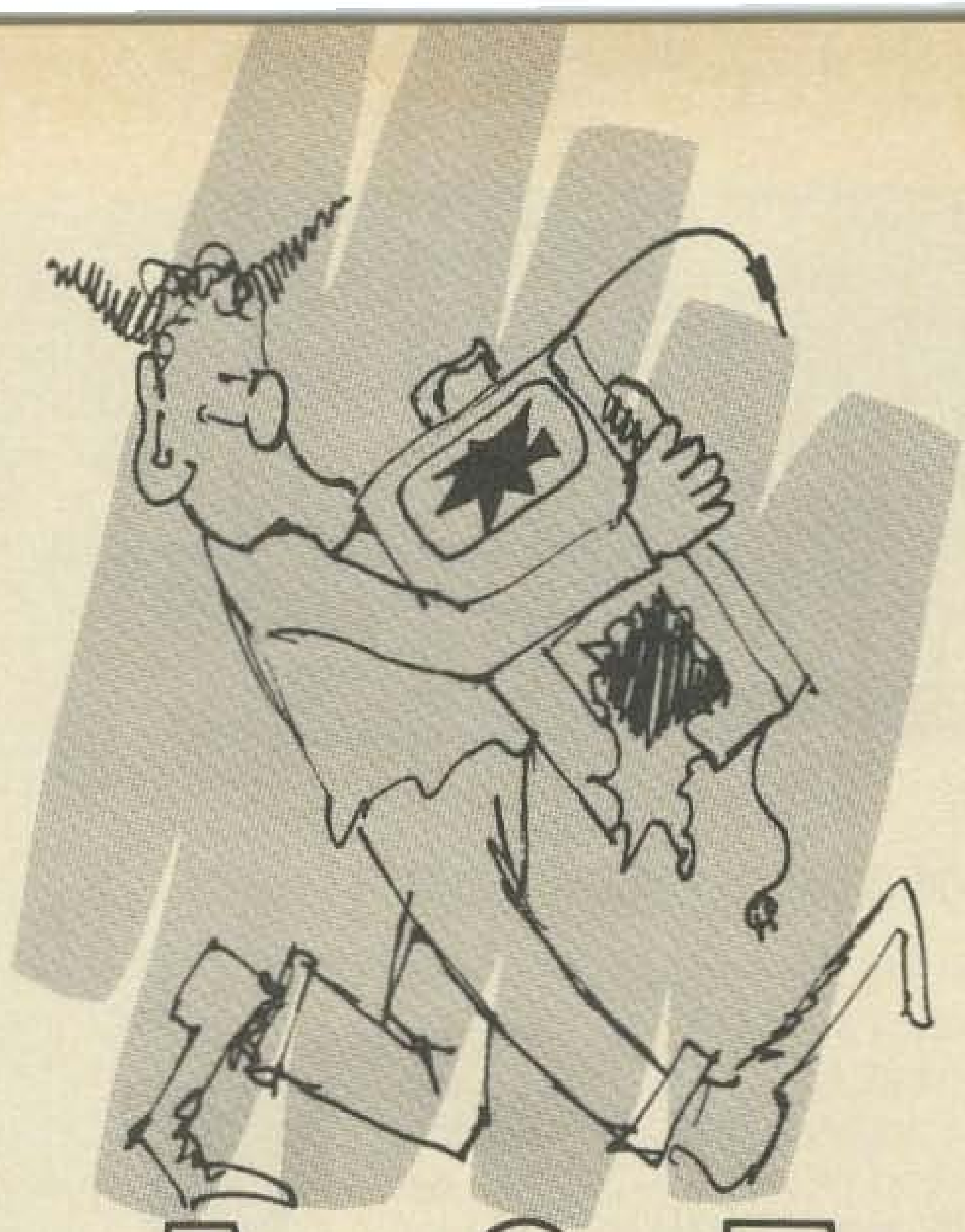
copy of my meter panel as Fig. 4. This can be copies or cut from the magazine and glued to the face of an appropriate 0–5 mA meter.

Reference:

Several other interesting circuits for the CA3018 are discussed in the RCA integrated circuits manual, where complete ratings and typical characteristics are listed.

. . .WB2EGZ ■

Guy Slaughter K9AZG
753 W. Elizabeth Drive
Crown Point IN



CAMOUFLAGE

Most *73* articles tell, but this one asks. The usual how-to piece gives counsel from one ham to many on what need be done to solve a stated problem, but this one reverses the process.

Because a quarter-million heads are better than one, advice is sought from the collective conscience of hamdom for the immediate benefit of one amateur – namely me.

In exchange for such desperately needed aid, I am prepared to provide similar-type advice in the same field acquired the hard way, through personal experience involving cut-and-try methods refined in the crucible of actual domestic confrontation.

Camouflage!

A recent proof of this pudding in my own background went this way:

Like this:

If you've bought a new piece of gear you're unable or unwilling to explain to your XYL, equipment costs being what they are and "holdout" money piling up in your wallet's secret compartment the way it does, here's the formula to follow:

Stopping off at a hardware store on my way home from Happy Harry's Ham Headquarters with a shiny new Drake R-4A under my arm in its shipping box, I bought the things a fellow needs under such circumstances.

The clerk said, pointing to my burden, "What ya got in the carton there, Charlie?"

Knowing him to be a big-mouth type who sometimes waits on my wife, I told him, "Frabbersnatches for my flibbergist, and the danged things leak. You got transparent masking tape and some window putty?"

He did have, so I bought some, added a can of red Rustoleum, and retired to my private – if shabby – office.

After sending my secretary (a nosy type who thinks more of my wife than she does of me) across town to get a signature on an obsolete deed from a guy I knew to be vacationing in Guatamala, I went to work.

Inside my sanctorum with the doors locked and my phone off the hook, I taped, painted and puttied.

In half an hour the new Drake looked like a World War II field telephone junction box nine years out in the rain. Switching the shiny black knobs for some assorted beat-up brown and gray ones I keep in my desk for just such purposes completed the transition.

I then carefully shredded the new shipping carton and the bill of sale into little pieces, flushed them down the office dooley, and stuck the Drake into a battered cardboard box the janitor used for his supplies.

Then I went home with it.

The XYL met me at the door, where I avoided her glassy eye by staring at her messy hairdo. "Been to the beauty shop today, Honey?" I asked in hearty greeting.

She mumbled something unintelligible, turned up her nose at the Drake, and uttered those welcome words.

"I wish you'd quit hauling that junk home to fix for your rotten friends," quoth she.

See how easy it is?

Of course, after a few weeks the paint-streak rust spots and the putty scars can be wiped off the gear, a little at a time, the protecting tape stripped away, and the original knobs replaced one by one.

If the transitional work is done gradually, your resident enemy won't notice that the beat-up box has been transformed into a thing of beauty.

On the other hand, if she or the spies she has mothered are the observant type, you can leave the camouflage in place until you're ready to trade it off for a new goody.

Either way, scarred up or cleaned off, the receiver's utility as a signal-catcher won't be affected by its exterior appearance, though your well-being may be.

In the same way, I've quietly acquired through the camouflage system a 24-hour digital readout station clock, swr bridge, coax switch, electronic bug, VTVM, scope, mobile rig, and beam rotator, all on hold-out money and all without attracting my wife's attention.

I recommend the system unequivocally.

But now comes the problem, and here's where I need help and advice.

So far, my camouflage activities have been relatively minor-league, not really preparing me for the major-league ordeal ahead, the crucial crisis that separates the men from the boys.

Please, you out there, rescue me with some counsel: How do I smuggle up in my back yard (without the XYL noticing it) the new 50 ft mast and tribander hidden in the basement of my office building?

. . . K9AZG ■

Mr. Jim Kyle K5JKX
2612 NW 24
Oklahoma City OK 73107

THE PHASE-LOCKED LOOP COMES OF AGE

It's been a little more than 13 years now since the idea of "synchronous detection" entered the ham radio world – and the odds are, unless you're a dedicated VHF and DSB (yes, we said *D*SB) nut like I am, you still haven't heard very much about it.

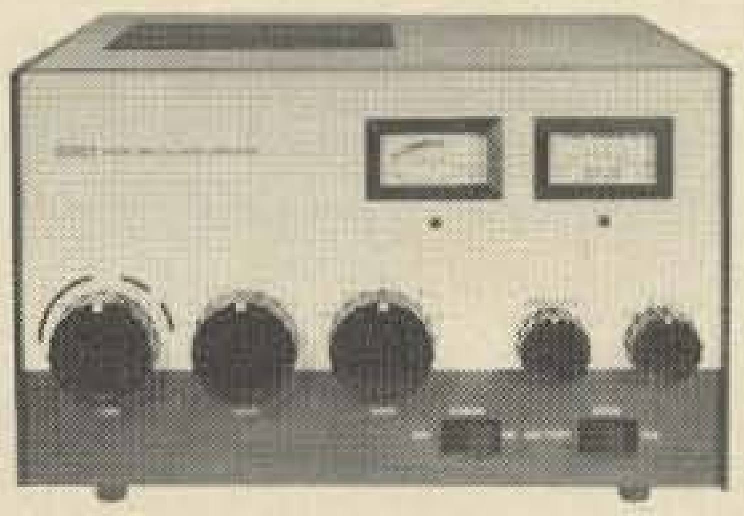
Not that some of us haven't done our part. The initial publication of an article of the subject back in 1957 (three years before *73's* birth) was accomplished under Wayne Green's guiding hand in CQ Magazine, and the next synchronous-detection bombshell (conservatively titled *50 dB Under the Noise – A Breakthrough*) saw the light of day in the short-lived pages of 6-Up, *73*'s subsidiary VHF magazine of the mid-60s.

But all the way through, the synchronous detection ideà has had a tough obstacle to battle: While it does give all the performance claimed for it, it requires several times as many components as does a conventional detection circuit. The 1957 version used eight double-section tubes to give 16 stages; the 1964 edition (actually a completely separate implementation of the same basic idea but giving other features) was solid-state and required 24 transistors.

Quite obviously, this is a larger stage count than that of many complete receiver designs. So long as so many devices were necessary, the synchronous-detection idea just couldn't make it in the face of its much simpler competition.

But all that was changed in the last year when a major manufacturer of integrated circuits put together a single-chip circuit which does just about everything required for the synchronous detector, in a single standard-sized 16-lead dual-inline IC package. Although it contains approximately 50 transistors, the whole thing takes only

SB-35...great new transceiver



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- Output, 50 ohms. Adjustable pi network.
- Power supply built-in, 115/240VAC, 50-60Hz.
- Built-in relays.
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- Weight: Approximately 50 pounds.

See these great ones at your SBE dealer and also write for full line brochure.

The SB-35 Transceiver

- 5 bands: 3.5-4, 7-7.5, 14-14.5, 21-21.5, 28-28.5, 28.5-29, 29-29.5, 29.5-30 MHz.
- 260 watts p.e.p. input.
- **Built-in,** power supply, 12VDC **and** 117VAC.
- Selectable SB's: LSB, USB CW w/zero car. shift.
- CW keying--shaped--carrier re-insertion type.
- Offset--no leapfrogging on transceive.
- Double conversion receiver.
- Crystal lattice filter in 2nd I-F with shape factor of 1:1.9!
- **97% all solid state!** 30 transistors--8 FET's, low noise hot carrier diodes in balanced mixer.
- Only 2 tubes. Type 8417 hi-fi types matched for low distortion. **Not** TV sweep types.
- Accessories that fit **inside** of cabinet w/bottom of cabinet controls include VOX, 25kHz calibrator.
- External VFO accessory.

SBE

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about 10 mA from an 18V supply, and is hardly as large as a commemorative postage stamp.

And to top it off, the price of the device is surprisingly low, considering what you get. There are several different versions with different features, but the least costly of them is still a complete FM receiver which accepts a minimum 300 μV signal (across 3 kΩ) at any frequency from 100 Hz up to 60 MHz or so, with any deviation up to +20% of center frequency, and produces 60 mV of audio output across 8 kΩ. This one costs $30 in single-lot quantities, according to the most recent price list, but that's all you need for a complete receiver within its frequency range and sensitivity.

On top of this, remember that these are current prices, and the unit is not yet in wide use. If it catches on as it apparently should, the cost is bound to come down. Remember when the CK-722 transistor sold for $7.50 each? And now they're down to 4 for $1 from the mail-order houses?

What Is Synchronous Detection?

The words "synchronous detection" have been applied to many different detection schemes, but all of them share the idea of using a stable local oscillator to mix with the incoming signal, and developing an error signal should the local oscillator get off frequency. You might call it a sort of superhet receiver, with automatic frequency control and a zero-frequency i-f, if that brings any reasonable picture to mind.

The most common type of synchronous reception currently used (yes, it *is* being used – by radio astronomers, space communications systems, long-range radar, and any place else that the ultimate in radio communications is required, thus justifying the complexity and cost of the older approaches) involves a "phase-locked loop."

The phase-locked loop includes a phase detector, a low-pass filter, and a voltage-controlled oscillator. The phase detector is a circuit which accepts two different rf input signals, and produces a dc-to-audio output signal which reflects the phase differences between the two inputs. That

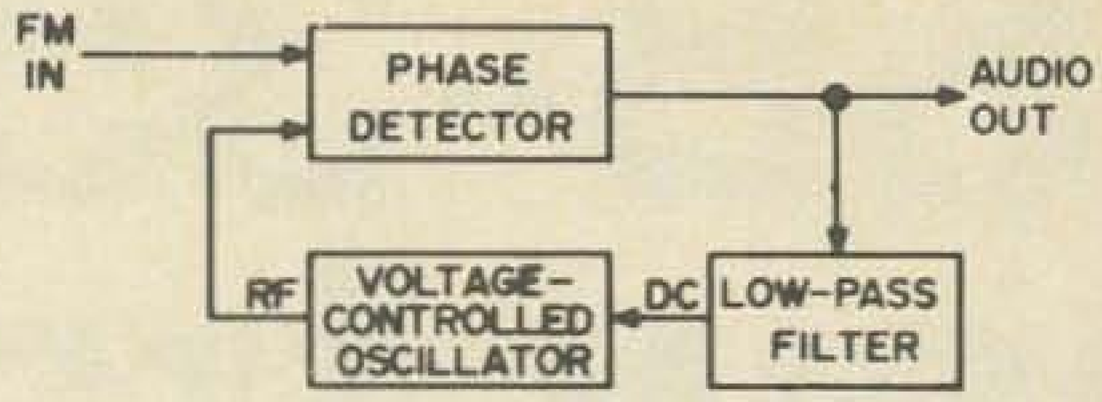

Fig. 1. Basic phase-locked loop or synchronous detection hookup for FM reception uses voltage-controlled oscillator in a servo loop. Output of VCO is continually compared with input signal in phase detector, which produces an output consisting of dc voltage which varies as input frequency changes (which amounts to superimposed audio). Low-pass filter wipes off audio and dc goes to VCO to keep it locked to input signal. Unfiltered error voltage from phase detector is the audio modulation of the signal.

is, so long as both inputs are in the same phase relation to each other (usually 90 degrees), output of the phase detector is zero. If the phase of input A begins to lag, output goes positive, and if input A begins to lead the other, output goes negative.

If we could keep an oscillator absolutely stable on the center frequency of an FM transmission, we could feed its output to one input of the phase detector, and feed the other input with the FM signal. The output would then faithfully reproduce the phase differences, which would reproduce the audio signal envelope.

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And that's the way the phase-locked loop (abbreviated PLL) works. The phase-detector output is filtered to remove any audio and retain only the dc component, which is a measure of the drift in the local oscillator, and then applied as an "error signal" to the local oscillator to keep it locked in phase with the incoming FM signal.

The filter keeps the voltage-controlled oscillator (VCO) from following the audio, so we pick the audio off ahead of the filter, and we have an FM detector (Fig. 1).

For AM reception, we do things a little differently. We lock the VCO to the incoming signal, just as before, but we add things.

It works out to be something very much like SSB reception; many years ago QST pushed something they called "exalted carrier reception," which involved using two i-f strips, one extremely sharp to pick out the carrier from between the sidebands for high-gain amplification, and the other to accept the sidebands.

Our phase-locked AM reception is just about the same, except that we generate a new carrier in the VCO which is phase-locked to the incoming carrier, and use that to demodulate the sidebands. The demodulation is accomplished in a "multiplier circuit" which is more familiar to most of us as a "product detector" or "mixer." Another low-pass filter shaves off the original input-frequency signal, the VCO signal, and the *sum* frequency from the product detector's output, leaving us the *difference* frequency, which turns out to be the audio we wanted to recover.

Note that this arrangement (Fig. 2) cannot demodulate an SSB signal since

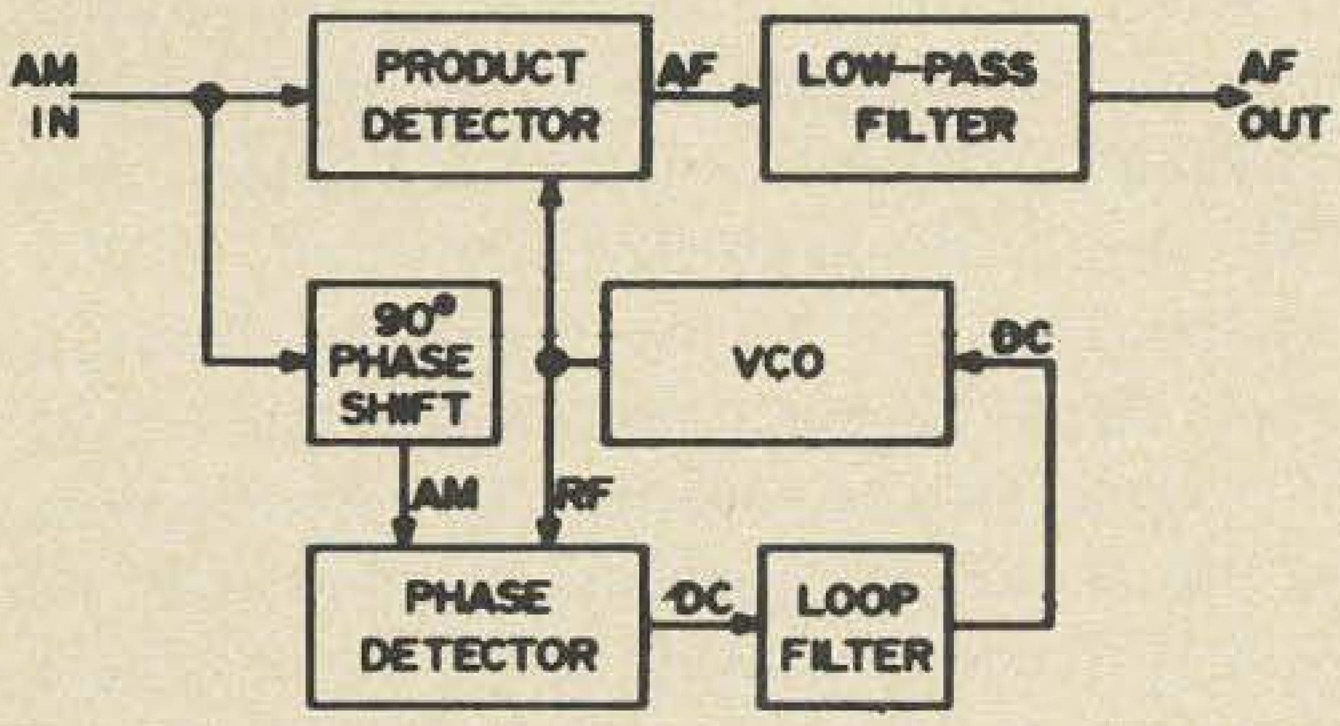

Fig. 2. AM detector using phase-locked loop is a bit more complex. Incoming AM is shifted 90 degrees in phase and VCO is then locked to it. VCO output is used as bfo input to product detector, to recover audio. Low-pass filter in audio signal path removes intermediate, VCO, and sum frequencies, leaving only the difference-frequency output of the product detector.

there is no carrier present for the phase-lock loop to lock onto. In such a case, it would attempt to lock on the strongest sideband component present with notably less than satisfactory results.

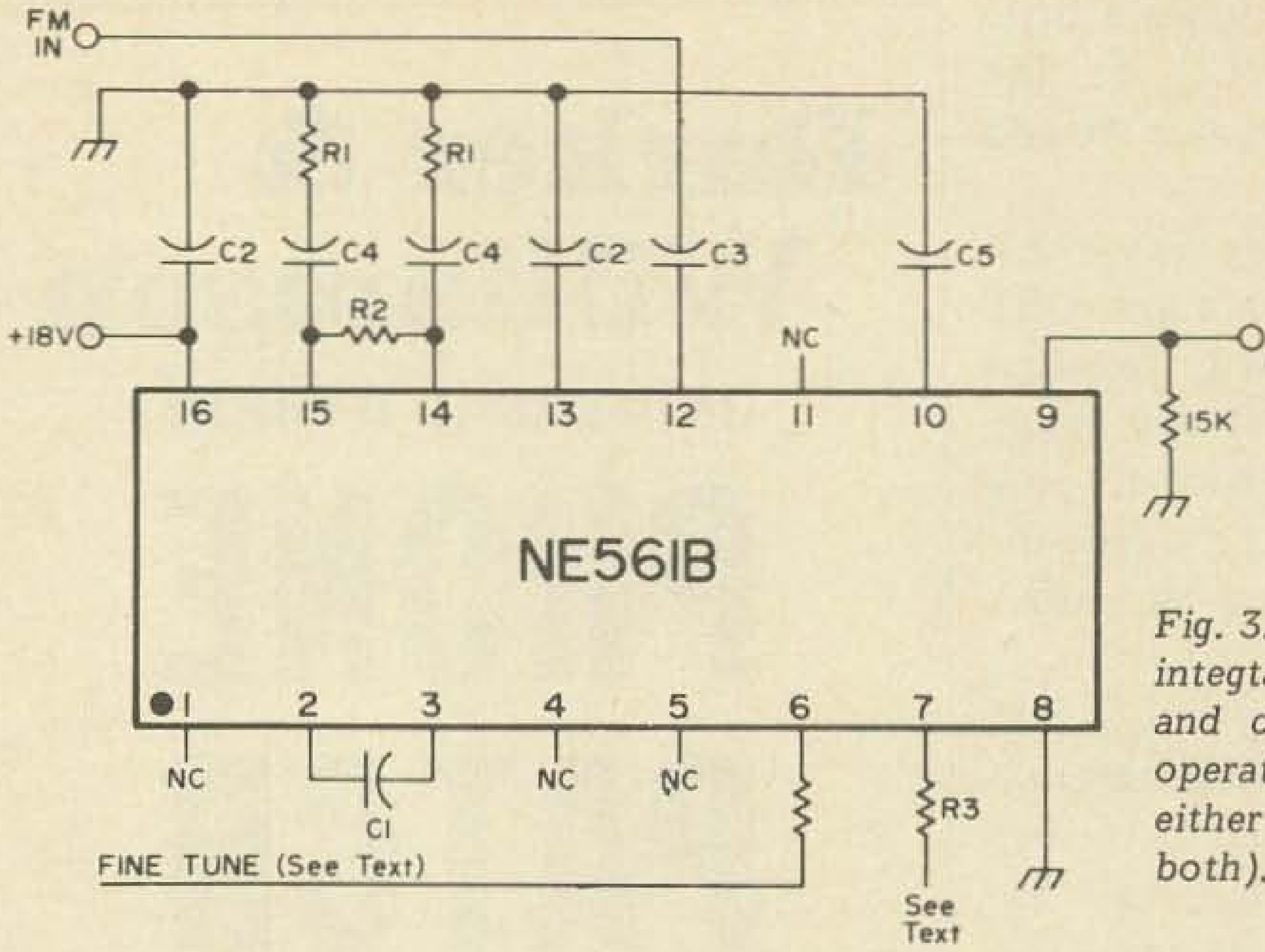

Fig. 3. Practical versions of PLL using integtated circuit with external resistors and capacitors to select frequency of operation. FM input may be applied to either pin 12 or 13 (or push-pull to both).

The 1957 circuit, by Dr. John Costas W2CRR and G. K. Webb WØAHM/2 (both with General Electric in Syracuse, N. Y. at that time), overcame the problem by deriving the control voltage for phase-locking from the sidebands rather than from the carrier. Unfortunately, their circuit has not yet been implemented on an integrated-circuit chip so far as we have been able to learn and so we must wait a bit longer for that happy time.

Right now, though, we can build an FM receiver with excellent performance which will also be able to detect conventional AM, for a small fraction of the cost of conventional receiver circuits.

How Can We Use Phase-Locked Loops?

No new component, no matter how interesting it may be, is of much good to many of us unless we can put it to use. The logical question at this point, then, is "How can we use phase-locked loops?"

In the initial report describing the IC phase-locked loop, Dr. Alan B. Grebene listed nine electronic circuit functions for which he felt it was well suited:

1 – FM i-f strip and demodulator for commercial FM receivers.

2 – Commercial TV sound i-f and demodulator.

3 – Tuned AM detector.

4 – Self-contained SCA (storecast music) receiver.

5 – FM/multiplex telemetry receiver.

6 – Signal conditioner and limiter.

7 – Frequency-shift telegraph receiver.

8 – Frequency selective multiplier and divider.

9 – High-linearity FM detector for wide-deviation FM.

To his list, we can add several more directed specifically at amateur use:

10 – VHF FM mobile receiver for compact cars.

11 – VHF FM handheld receiver.

12 – Frequency synthesis for high-accuracy VHF FM transceivers (*Boelke, 73*, Feb. 1970).

Some of Dr. Grebene's suggested applications are outside our scope, such as the telementry receiver, signal conditioner, and TV sound demodulator. Several of the others telescope into a single application when signal frequencies are ignored – that of a versatile FM receiver. So let's see how to use the PLL (phase-locked loop) IC as an FM receiver, as an AM receiver, as a frequency multiplier, and as a FSK RTTY converter.

Let's emphasize that the circuits which follow are taken from the manufacturer's published applications notes and literature; we have not breadboarded any of them and so cannot guarantee results (but let us know if you have troubles with any of them).

FM Receiver

FM reception is simple with the IC PLL; that's the job it appears to have been invented to do in the first place. When it's running "locked" to a signal, the average dc level of the phase-detector output is

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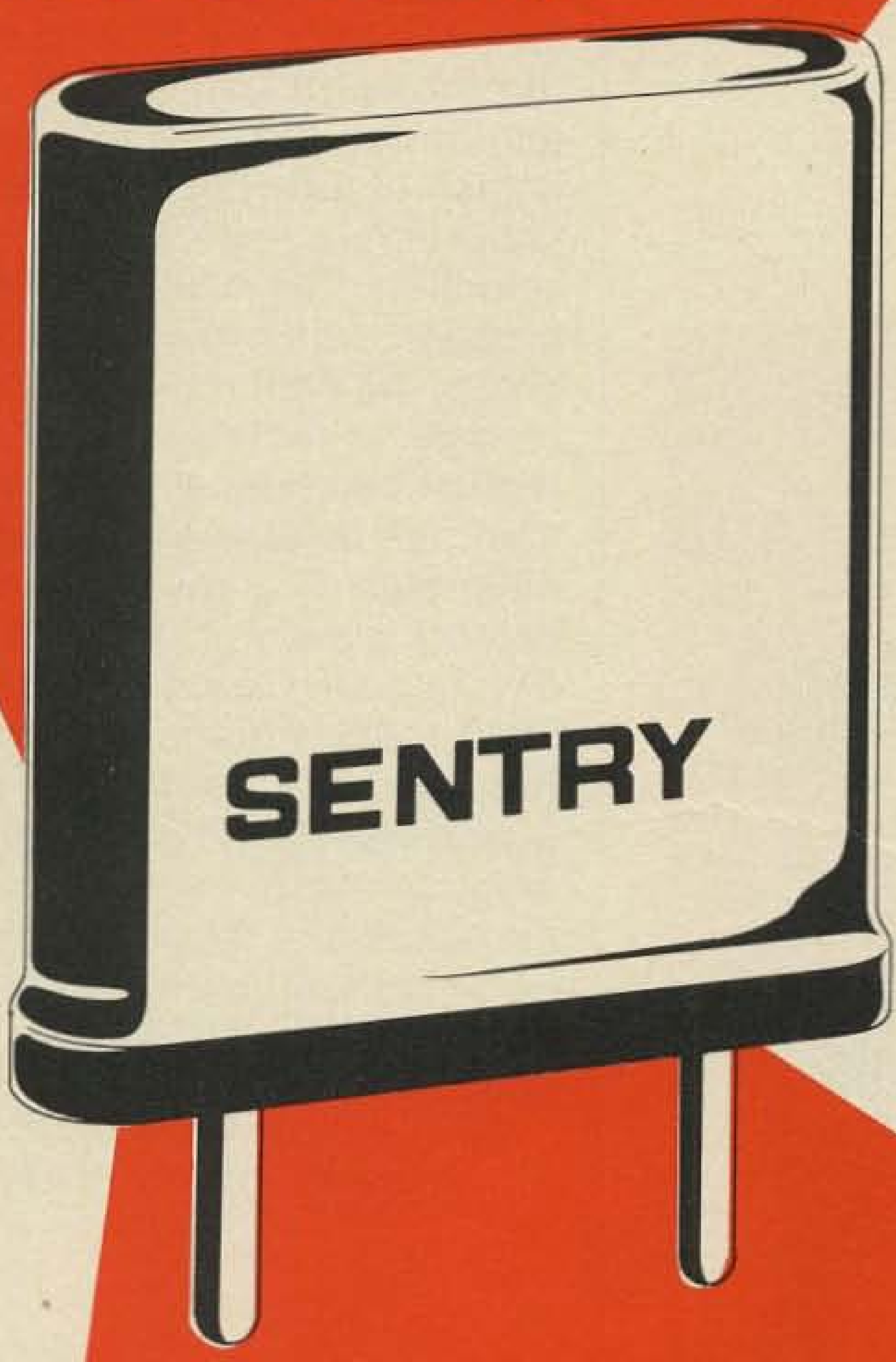

Somewhere along the line, in virtually every ham repeater in the world, you'll find a couple of Sentry crystals.

Repeater owners and FM "old-timers" don't take chances with frequency—they can't afford to. A lot of repeater users depend on a receiver to be on frequency, rock stable...in the dead of winter or the middle of July. The repeater crowd took a tip from the commercial "pros" a long time ago—and went the Sentry Route.

That's one of the reasons you can depend on your local repeater to be there (precisely there) when you're ready to use it. FM'ers use the repeater output as a frequency standard. And for accuracy, crystals by Sentry are THE standard.

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directly proportional to the frequency of the input signal. As the input frequency shifts with modulation, it's this dc output that changes and causes the VCO to shift its frequency to remain locked on the input signal.

The only problem to face in building an FM receiver with the IC PLL is that of setting it up for the proper input signal frequency. The VCO center frequency is set by an external timing capacitor, and by varying the value of this capacitor we can work at any frequency from 100 Hz up to a guaranteed 15 MHz, with typical units operating to 30 MHz and operation as high as 60 MHz possible by a trick we'll pass on a little later.

The connections necessary, as well as the external components required, are shown in Fig. 3. Capacitor C1 is for timing; its value in picofarads for frequencies in the range from 100 Hz to 30 MHz is shown in the left-hand graph of Fig. 4. This capacitor provides a "coarse" adjustment of frequency which can be trimmed by variation of capacitor value. For "fine" frequency adjustment, current must be injected into pin 6 through a series resistor from the power supply; the right-hand graph of Fig. 4 shows the percentage of frequency change achieved for various values of current injection.

The other capacitors shown in Fig. 3 are bypass capacitors (C2), coupling capacitors (C3), and low-pass filter capacitors (C4). Their values are dependent to some degree upon the center frequency chosen. The deemphasis capacitor (C5) should be larger than 200 pF for commercial FM reception;

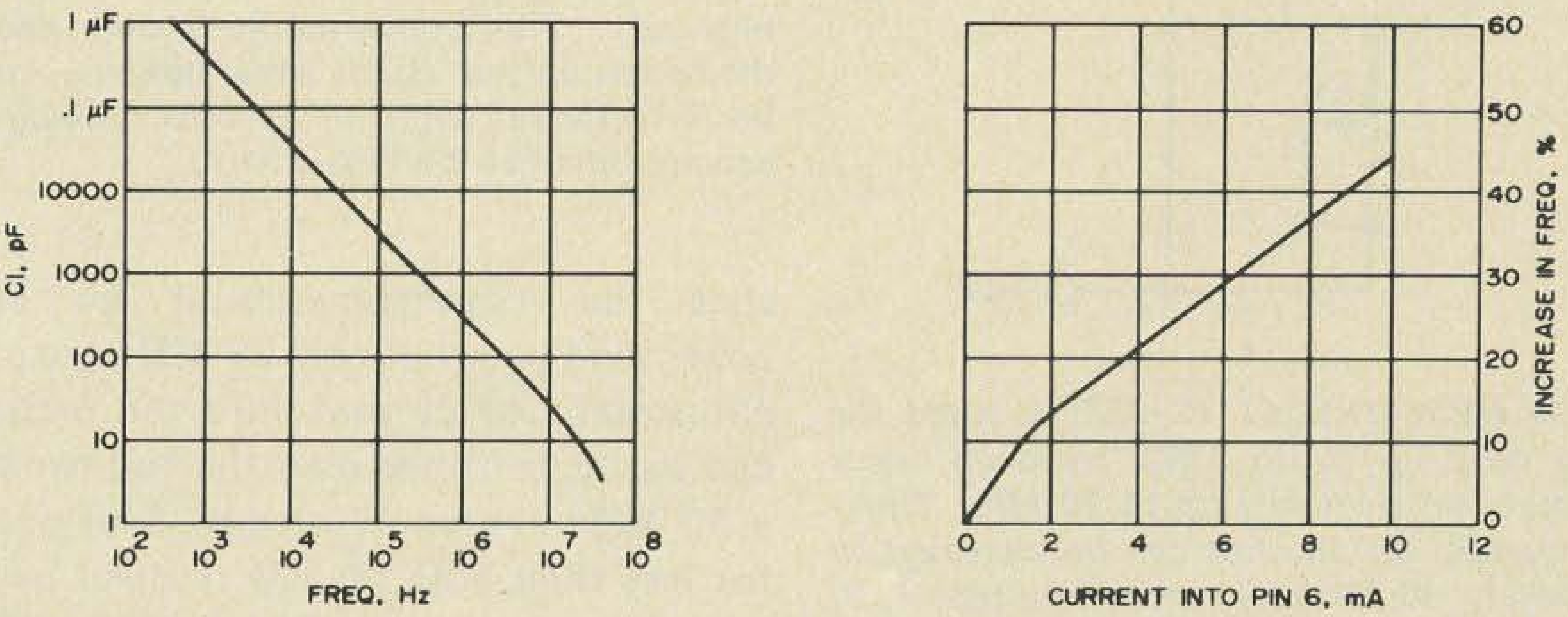

Fig. 4. These two graphs show how operating frequency of VCO in IC PLL is set. Graph at left shows approximate center frequency as value of C1 is changed through the range from 1 µF to 10 pF. This is coarse frequency setting, determining lowest operating frequency. Graph at right shows how frequency increases as current is fed into pin 6; approximately 45% increase in frequency can be attained by this means. This provides "fine tuning" control.

its value is subject to experiment for communications purposes.

Resistors R1 together with capacitors C4 form the low-pass filter; it's fed by an internal impedance of 6 kΩ at pin 14 or 15. Typical values for R1 and C4 are 50Ω and 1100 pF.

The locking threshold of the circuit may be controlled by connecting resistor R2 across pins 14 and 15. Resistor R2 is normally left out, but at high input signal levels or high input signal frequency this reduction in threshold may be necessary to prevent instability. Approximately 6 kΩ is a typical starting point; the value of R2 should be as high as possible in any specific case, though.

Tracking range may be controlled by current injection into pin 7 through resistor R3. If R3 is omitted, tracking range will be approximately 15% of center frequency. When R3 is set to a value which permits 0.65 mA of current to flow into the 600Ω impedance at pin 7, this figure is reduced to approximately 3%.

Other controls are possible, but should not be necessary when the PLL is used as an FM receiver. Input signal level should be at least 120 μV to either pin 12 or 13 (the unused input pin should be ac-grounded through a bypass capacitor). Output at pin 9 across a 15 kΩ external resistor (which must be in the circuit; this is an open emitter in the IC) should average 60 mV.

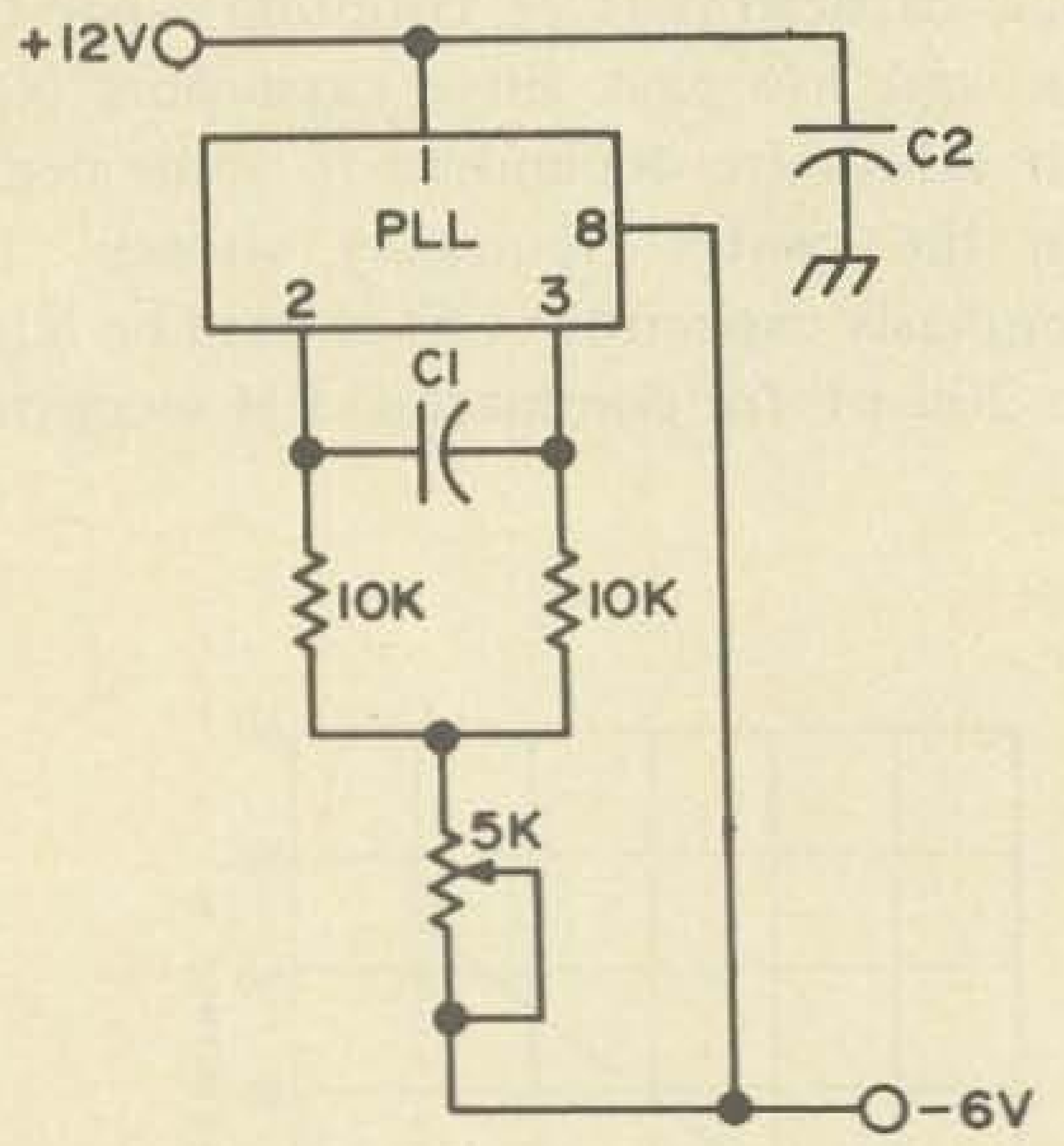

Fig. 5. The NE560/NE561 IC PLL is rated for operation only up to 15 MHz, although many units operate satisfactorily up to 30 MHz. Operating frequency for all units can be increased to approximately 60 MHz by connecting pins 1, 2, 3, and 8 as shown here. This modification can be applied to any of the accompanying circuits. The 5 kΩ pot serves as a fine-tuning control, replacing the current injection into pin 6. If current injection is to be used, the pot can be omitted from this circuit.

For VHF operation of the PLL, two 10 kΩ resistors and a 5 kΩ pot should be added externally as shown in Fig. 5. According to applications engineer Ralph Seymour, this modification extends the frequency range up to 60 MHz. The 5 kΩ pot provides convenient fine-tuning of center frequency, and may be omitted.

Because of the comparatively high signal level required, and the low input frequency (when compared to the 2 meter band, for instance) a VHF FM receiver for ham use of the PLL would require a converter ahead of the PLL circuit. A block diagram of such a hookup appears as Fig. 6. Note

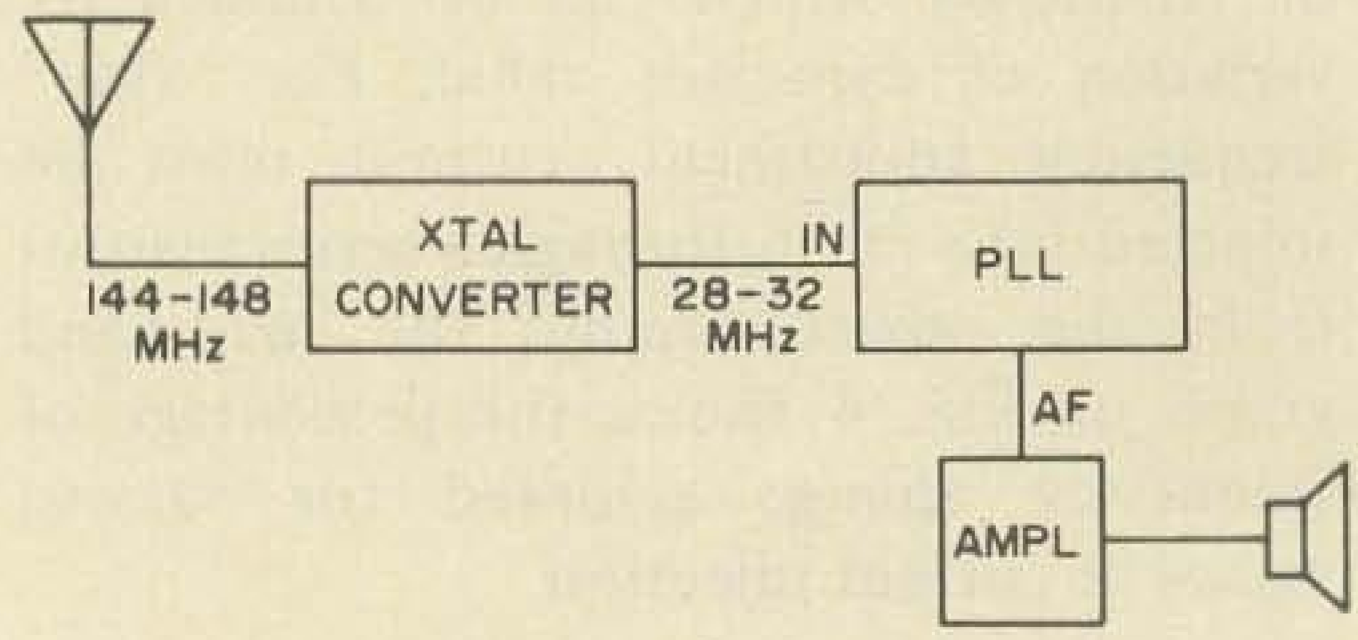

Fig. 6. For ham use as a VHF FM receiver, a crystal-controlled converter ahead of the PLL is necessary. This converter need only provide a moderate output signal level, however, and can be broadband with all receiver tuning being accomplished at the PLL circuit.

that the converter could be crystal-controlled to produce a 28 MHz output; by adjustment of current into pin 6 the PLL can easily be tuned over the full band from a 30 MHz center frequency. This provides, for less than $50, an FM receiver based on the time-honored 75A4 principle of crystal-controlled front end and tunable i-f.

AM Receiver

The AM reception capability of the PLL is something of an "extra." The PLL is

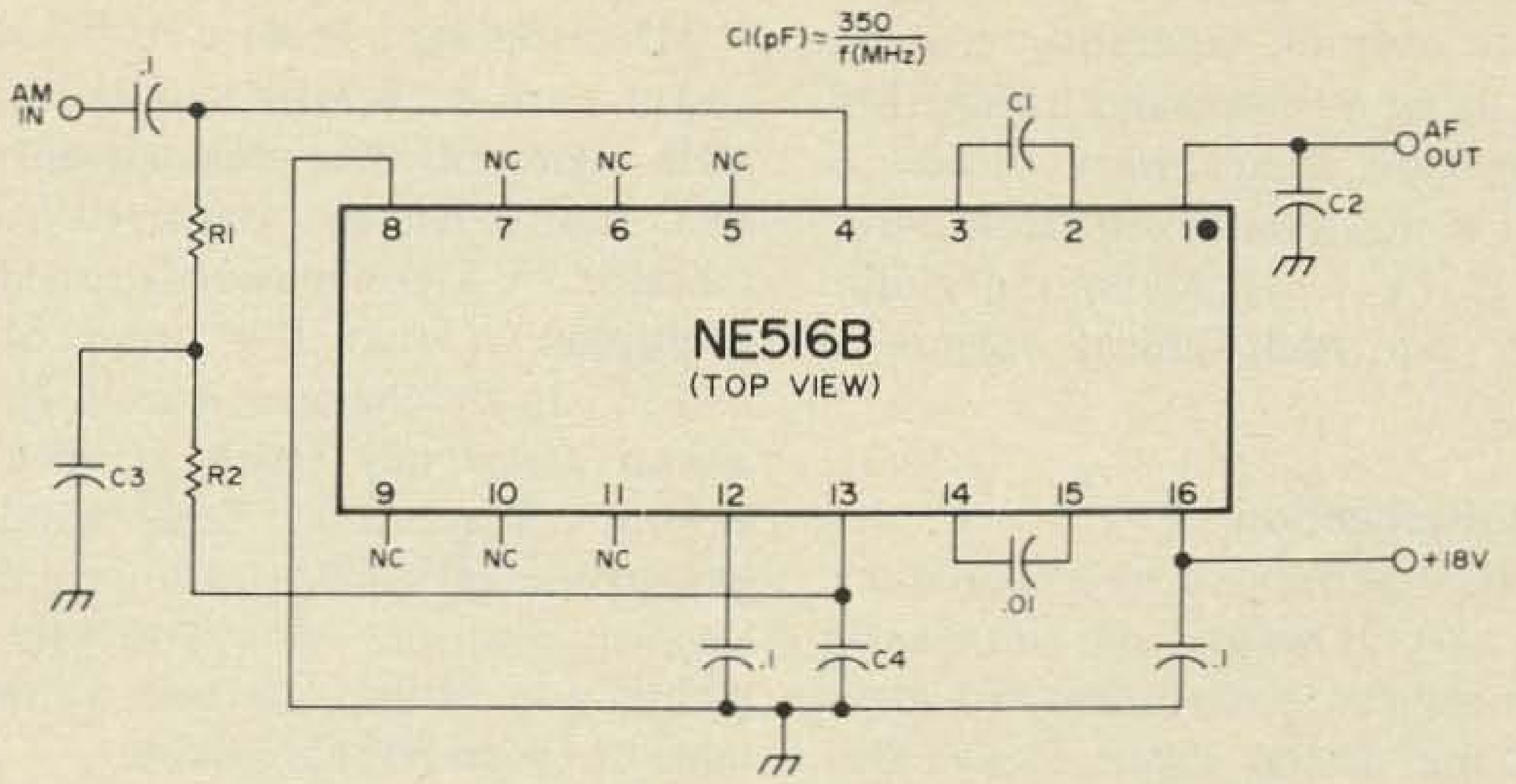

Fig. 7. This is a BC-band AM receiver using the NE561 IC PLL (the NE560 does not include AM detection capability).

locked to input signal carrier frequency and its output is used as the local oscillator to a built-in product detector. A 90-degree phase shift is required to obtain proper operation.

Figure 7 shows the hookup. Bypass and coupling capacitors, all shown as 0.1 μF, should have low impedance at operating frequency (this circuit is intended to cover the BC band rather than HF or VHF). Capacitor C1 is selected to obtain the proper center frequency, and C2 sets the bandwidth by filtering off high-frequency audio output.

The phase-shift network (R1–2, C3–4) provides 90 degrees of phase shift for the rf input signal; the sum of R1 and R2 should be less than 5 kΩ (2 kΩ each was the value used in the prototype) and C3 and C4 should have reactance equal to the values of R1 and R2. For BC operation, 82 pF was chosen.

In this hookup, the low-pass filter is not critical, since no audio is taken from the loop itself; so a simple 0.01 μF capacitor from pin 14 to pin 15 suffices.

Tuning may be done in either of two ways. The first is more straightforward but the second is elegant. The first way is to vary the value of timing capacitor C1. For BC operation, C1 should tune from a minimum of 220 pF (for 1600 kHz) to a maximum of 620 pF (for 500 kHz). The classic receiver alignment technique of padding capacitance is used at the high end of the range, but at the low end varying the current into pin 6 (fine-tuning control) takes the place of adjustment of inductance.

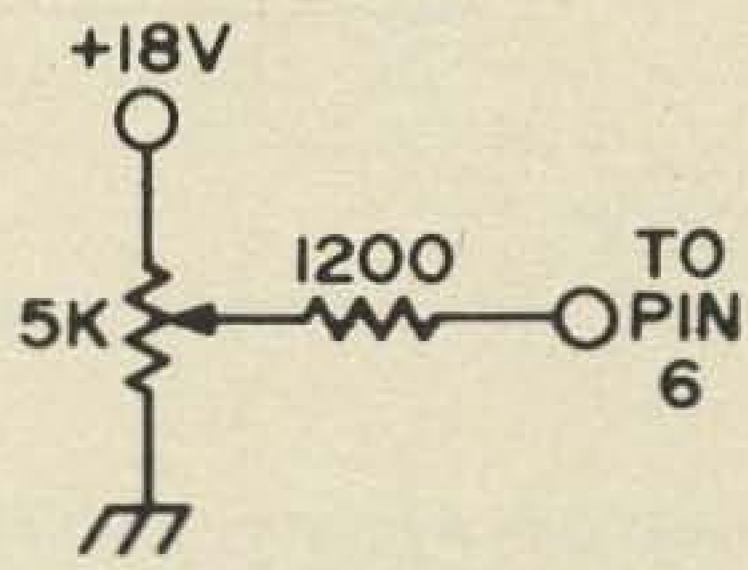

Fig. 8. This simple arrangement for connection to pin 6 of NE560/NE561 provides fine tuning over a 3:1 range. The 1.2 kΩ resistor limits maximum injection current. Timing capacitor should be set for lowest frequency with pot arm at ground, and 1.2 kΩ resistor then trimmed to set highest frequency desired, with pot arm at hot end.

The second method of tuning the receiver uses a fixed value for C1. This value is whatever is required to make the VCO operate at 940 kHz (geometric mean frequency) when the current at pin 6 is zero. Pin 6 is then connected through a 1.2 kΩ resistor to the arm of a 5 kΩ pot (Fig. 8) across the 18V power supply. Varying the pot tunes the receiver across the BC band using only the fine-tuning feature.

This receiver requires an antenna and a good ground; it must get at least 100 μV from pin 9 to ground. Operation will be improved by using a broadband untuned rf amplifier, but care is necessary to assure that the PLL is not overdriven (maximum input signal if 1V rms). Maximum audio output is 2V p-p, and typical output is about 60 mV.

Frequency Multiplication

The PLL IC can be used as a frequency multiplier in several ways. The simplest is merely to set the center frequency to some multiple of the actual input signal frequency. However, as the higher (and thus weaker) harmonics are used for locking, the lock range decreases. If input frequency is fairly stable and rapid tracking is not required, this technique can be used to multiply by 2, 3, 4, or 5 times any input signal. Output of the VCO at pin 5 is a square wave.

Action of the PLL as a multiplier can be improved by converting the input signal to a square wave, which has much stronger harmonics than does a sine. When this is done, any output frequency up to 15 MHz can be produced from its tenth subharmonic (multiplication of up to 10 times).

Since the PLL output is already a square wave, rich in harmonics, this offers an opportunity for use as a frequency marker. Two PLLs in series could produce a 1 MHz standard from a 100 kHz crystal, and in turn a 10 MHz standard from the 1 MHz standard. One great advantage of the PLL multiplier as compared to a multivibrator or a conventional tuned-amplifier multiplier is that the order of multiplication can be changed merely by changing center frequency (such as with switched timing capacitors). This would permit generation of a 3.5 MHz square wave as the seventh multiple of a 500 kHz standard, giving you strong markers at the bottom edge of every HF ham band.

The PLL multiplier will divide frequency just as easily as it multiplies. If center frequency is adjusted to be one-third that of the input signal, the circuit still locks. This action occurs only for *odd* submultiples, however; for even divisions (half, quarter, eighth) it doesn't work. You can divide 3, 5, 7 or 9 only.

Extensions of these features make possible the construction of simple frequency synthesizers; too many PLLs are required to make them practical at present prices, but when costs come down they may well be worth investigating. Collins Radio's book "Fundamentals of SSB" (out of print since 1962, unfortunately) gives the principles involved if you're interested.

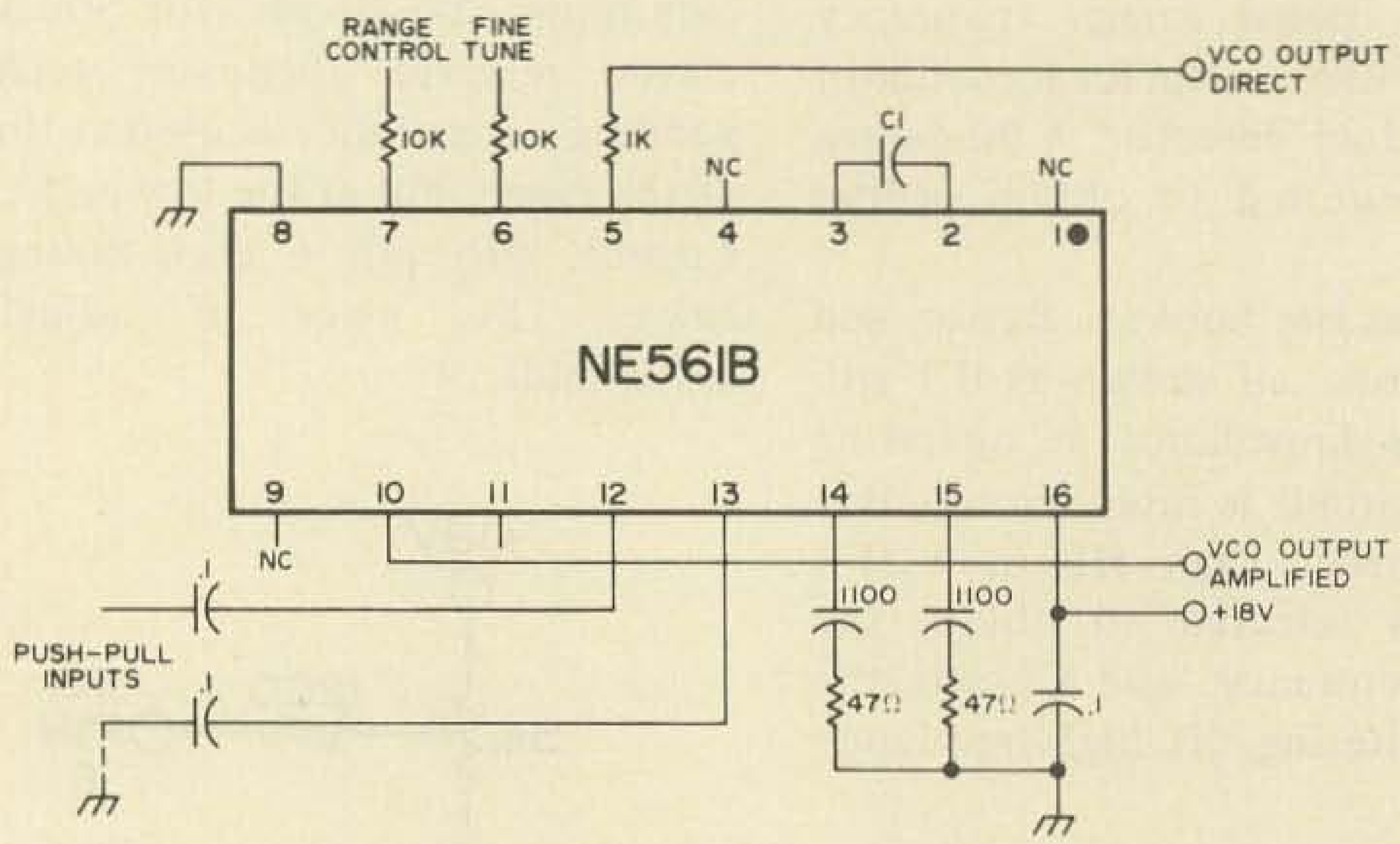

Fig. 9. PLL makes fine frequency multiplier or divider. For this application, audio output connections are ignored and the VCO output is used instead. If input is single-ended, one of the two push-pull input leads should be bypassed to ground as shown by dotted lines. Circuit will multiply up to 10 times, and divide input frequency by 3, 5, 7, or 9. C1 and fine-tuning adjustment must be set for operation near desired output frequency. When input is applied, VCO will lock to exact multiple or odd submultiple of input if it is within locking range and of adequate strength.

Some ~~Side~~ Snide Remarks about Raytrack

There are some people who marvel that a short wave receiver can tune in stations thousands of miles away. You and I know that this is normal and natural. There are some people who believe that only a linear whose name matches that of their transceiver will perform appropriately. You and I know their thinking to be wrong. But perhaps this confining view is just as well – for I doubt if Dan Eisenmann, for example, could make his Raytrack Horizon VI Amplifier the beautiful linear it is if greater customer pressure existed.

This six meter linear does not have a Raytrack transceiver to drive it with, it does not have a spurious input filter, it does not have automatic tuning, it does not have ALPL (Automatic Legal Power Limiting), and it wasn't designed to turn itself off in a microsecond if the antenna load wasn't connected to it. Worse, it does not have the latest zero drive tubes parallel connected to enable it to function at the mere thought of excitation. Dan wanted these features and more but we dealers did succeed in explaining that some of the six meter boys could tune an amplifier and read their meters correctly and that there were a few "technicians" who had been known to understand VSWR, and further if this new amplifier were made completely "idiot proof" that he did not have enough money to finance the deluge of orders that would result. Then we showed him he would have to borrow at the bank, and with interest the way it is today the bank would be taking in more than Raytrack. And, damn it, the boys in the shop would unionize (all three of them) and that too would mean more expense. Then if that wasn't enough the IRS would suddenly take notice and offer to carry their side of the wheelbarrow to the bank. And Dan, if that kept up for long, the next thing you'd realize is that our cousins in JA land would put their noses into the air and sniff a good thing, too. (Where would you be then, Mr. Frankenstein Eisenmann?)

And so reason prevailed. Raytrack did the proper thing, they concentrated on making an honest 2 kW six meter linear with *real* transmitting tubes that could be fed from anybody's Swan, Drake, or Heath exciter and with simple connections – only three of 'em – so clearly labeled that even Johnny Newham could hook it up right the first time.

And they soldered every joint and put a lockwasher where a lockwasher was supposed to be and finished their unit by testing it on the air and into a dummy load with proper instruments – and lo fellows, look what we got – and don't say that the price is high 'cause it ain't!

Study the photo and the specs and if you have something to listen with, tune me in, that is presuming that my demonstrator has not been sold (the last time it lasted 1½ hours – s' help me).

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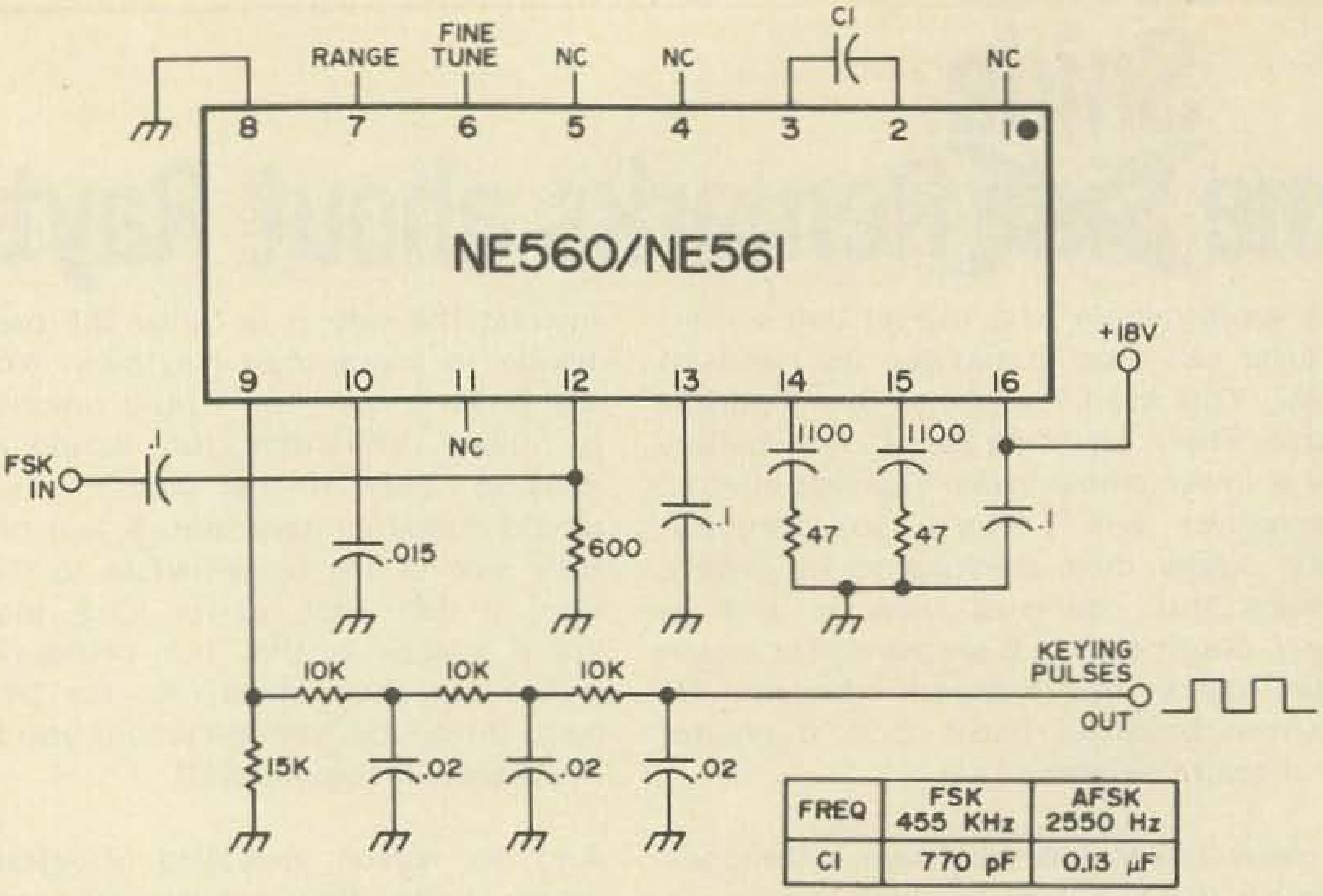

Fig. 10. RTTY converter circuit is taken from computer data set applications note; data set is same as AFSK converter, but gets input signal from telephone line and so is not subject to such high levels of interference as is RTTY. Input may be either at i-f or audio frequencies; table shows values of C1 for both cases. Output consists of pulses which may drive a keying circuit for selector magnets.

The hookup for use of the PLL as a frequency multiplier or divider is shown in Fig. 9.

FSK Converter for RTTY

Using the PLL as an RTTY FSK converter is almost identical to its use as an FM receiver, because FSK (or AFSK) is merely a means of carrying binary or telegraph (mark–space) information by means of frequency modulation. The frequency shift involved is usually rather small – but so is that for FM, in comparison with the center frequency.

The FSK input, either at communications-receiver i-f for FSK or at audio frequency for AFSK, is applied to the FM input of the PLL. The loop filter capacitor is made smaller than usual to eliminate any possibility of "overshoot" in the output pulse,

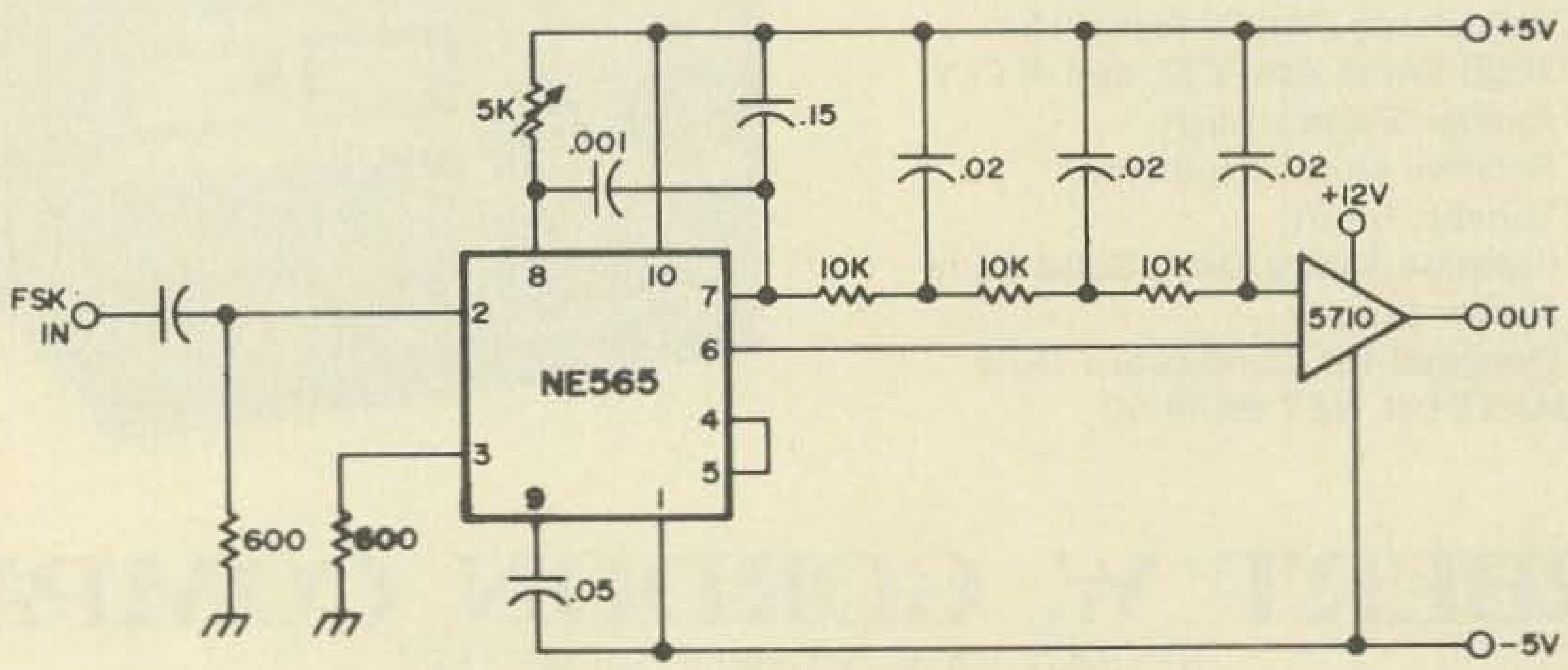

Fig. 11. Alternate RTTY circuit uses NE565 IC, which is so new that its price is not listed yet. Maximum frequency of 565 is 500 kHz. This circuit is designed to drive digital IC devices, and type 5710 voltage comparator is included to adjust output level to values suitable for digital ICs. Pot is for frequency adjustment.

and a three-stage ladder filter removes the carrier component from the output (this is necessary only for AFSK). The center frequency is adjusted to produce about 12V at the output when the input frequency is at its lower figure. When input frequency rises to its other figure, output will rise a maximum of 4V as the VCO tracks the input-frequency change. This voltage change is coupled out through output coupling capacitor to drive any external circuits desired, such as a magnet driver.

The circuit is shown in Fig. 10. Figure 11 shows an alternate circuit using a different type of PLL chip together with an IC voltage comparator at the output to for a center frequency of 67 kHz and tap off an output from your FM receiver ahead of the deemphasis filter (which bypasses the 67 kHz signal to ground) to feed the PLL. PLL output will then be the background music, which is free of all interruptions such as commercials or even station identification.

One precaution may be necessary. The signal from the FM receiver to the PLL input should go through a high-pass filter to prevent any possibility of overload by the much stronger audio of the normal broadcast program or any accompanying stereo information at 38 kHz. A typical hookup using the NE565 PLL is shown in Fig. 12.

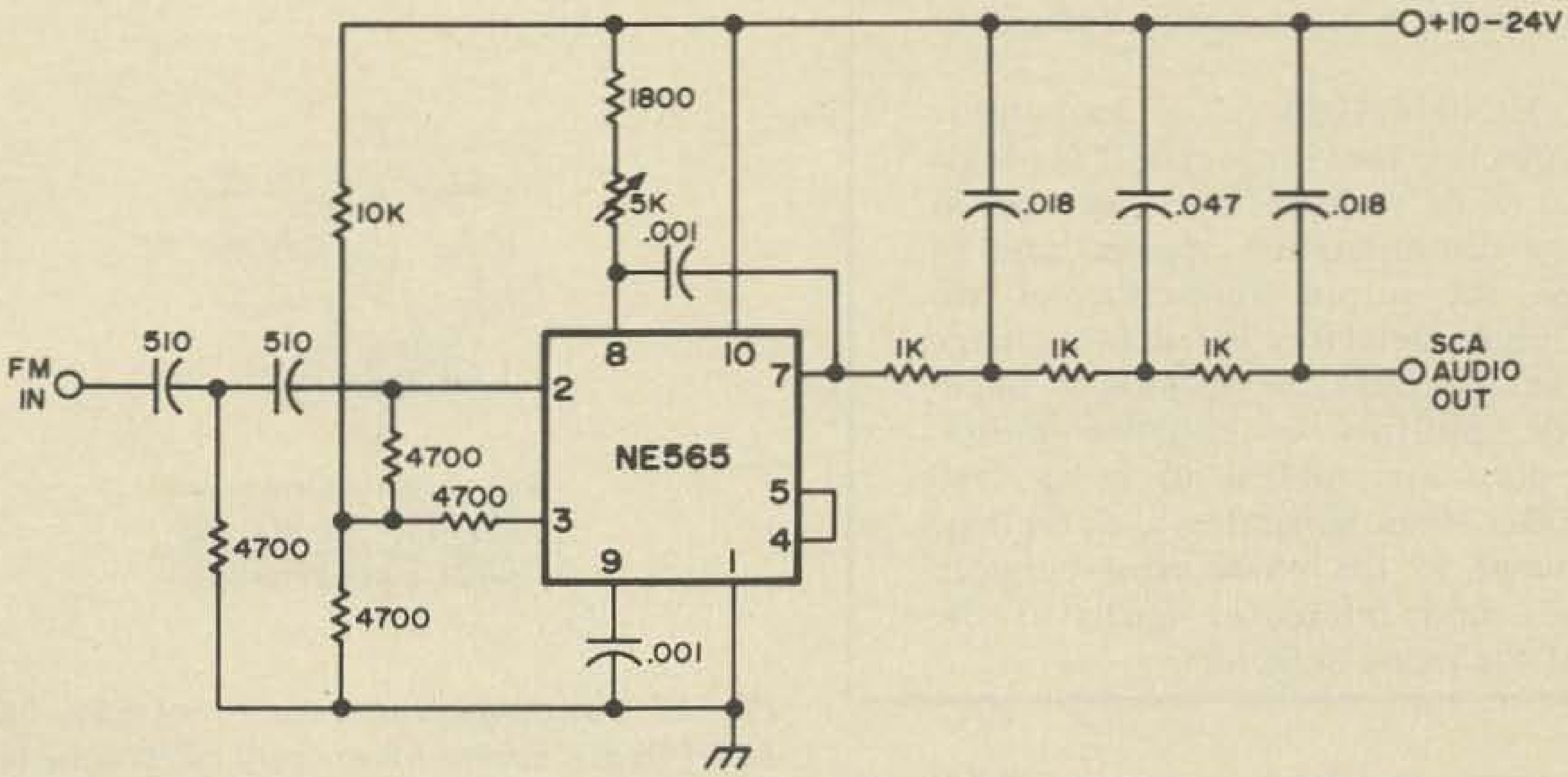

Fig. 12. Background music adapter for FM receivers uses type 565 IC PLL. 510 pF capacitors and 4.7 kΩ resistors at input form high-pass filter to keep audio from FM set from overloading PLL; ladder filter at output removes everything above about 10 kHz to keep from overloading audio amplifiers following. Pot allows frequency to be adjusted to 67 kHz to pick off SCA subcarrier.

change the output levels to values which are compatible with normal digital IC chips. In this case, center frequency is adjusted to produce a slightly positive voltage at the output, when input is at the low frequency.

SCA Adapter

The PLL's capability to receive FM at almost any center frequency comes in handy if you like background music from the "storecast" services sold by many commercial FM stations. These storecast signals are transmitted as FM of a 67 kHz subcarrier which is itself a part of the normal FM signal. To receive them with the PLL, all you need do is set up the PLL

The Source

About the only thing we haven't yet told you about the PLL IC chip is who makes it and where they can be obtained.

The manufacturer is Signetics Corporation, a subsidiary of Corning Glass Works and one of the leaders in the integrated-circuit industry for a number of years now. The PLL IC is only one of many chips in their line (their price list as of 4 May 1970 required 21 pages merely to list prices of current IC products).

Signetics is located at 811 E. Arques Avenue, Sunnyvale CA 94086, and we obtained our information from Ralph Semour, linear applications supervisor.

Three ICs Contain Entire Phase-Locked Frequency Synthesizer Loop

Except for the reference frequency component, designers can build the phase-locked frequency synthesizer loop portion of a system using just three IC packages. This is possible through the use of three new Motorola TTL circuits: a dual voltage-controlled multivibrator, type MC4324/4024; a phase frequency detector, type MC4344/4044, and one of two soon-to-be introduced modulo-N programmable counter, types MC4018. These three functions replace from 8 to 15 IC and discrete packages in a conventional phase-locked loop system.

The MC4324/4024 is a monolithic IC that contains two independent voltage-controlled multivibrators (oscillators). The frequency of the MTTL-compatible outputs can be varied over a range of 3.5 to 1 by using a dc control voltage of +1-5V.

The MC4344/4044 is a monolithic phase detector that converts TTL logic levels to a dc voltage level for use in frequency discrimination applications. In operation, the output from either of two internal phase detectors is fed to a charge pump that converts the outputs to fixed-amplitude positive or negative pulses. These pulses are applied to a lag–lead active filter that generates a dc voltage proportional to the phase error between the input and reference signals at the inputs of the phase detectors.

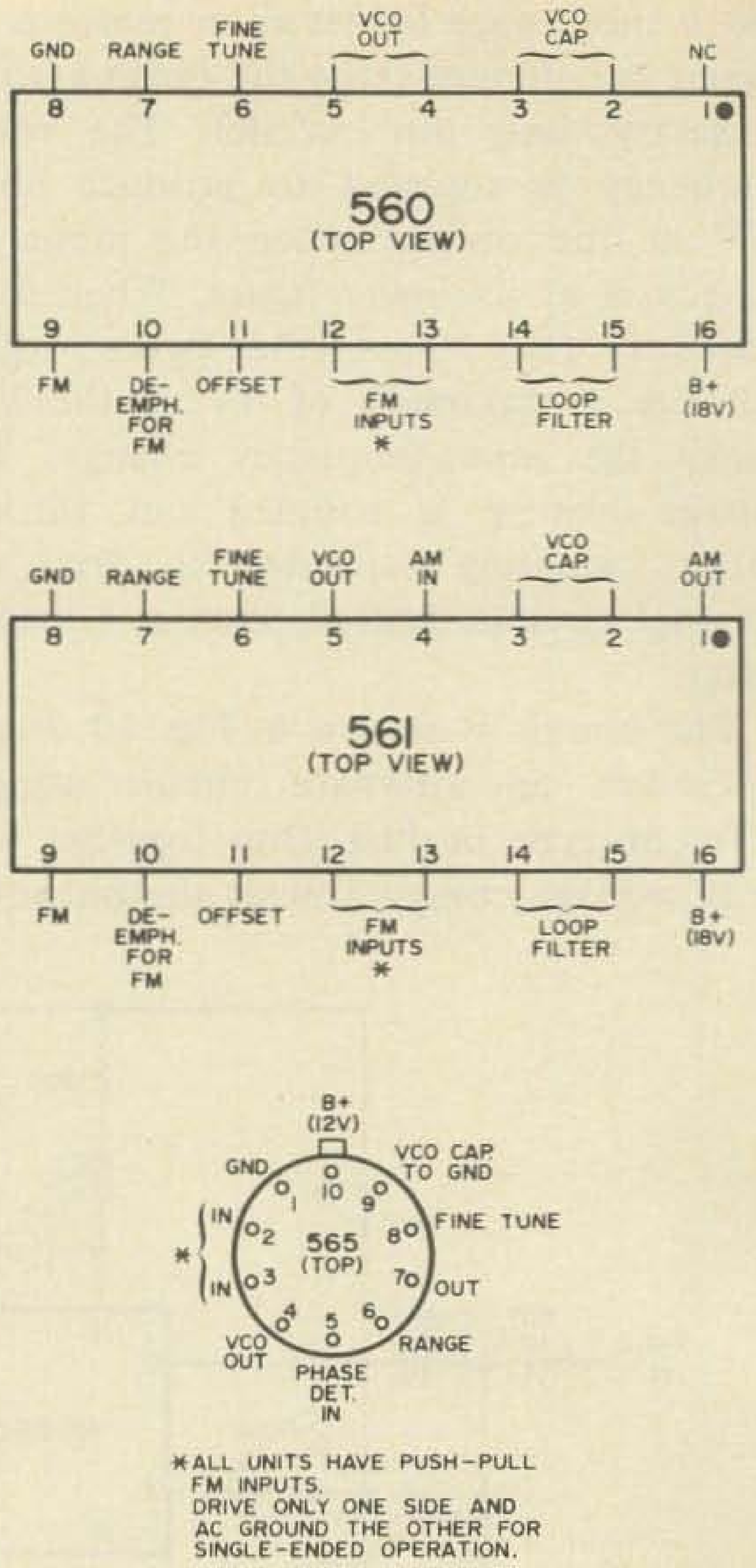

Fig. 13. Pin connections for types 560, 561, and 565 Plls are shown here. Only difference between 560 and 561 is that 561 has Am detector included where 560 has additional VCO output lead.

They make the PLL in several different models, with model numbers to match. The one shown in most of these diagrams is the NE561B, which is the most general in application. It includes the AM-detection capability, and quoted price in lots of 1-24 is $37.50 each. The NE560B is virtually identical but does not include the AM-detection features, and lists at $30 each. Models NE565 and SE565 (the N indicates *commercial* temperature range; the S means *military* range) are too new to be listed; they operate only up to 500 kHz and so presumably would be lower in cost. The 565 is used in the circuits of Figs. 11 and 12. Finally, the NE562 is intended for direct interface with digital logic systems and, like the 565 it is too new to have an established price yet.

Pin connections for the 560, 561, and 565 are shown in Fig. 13.

The N5710T comparator shown in Fig. 11 sells for $2.62 each in lots of 1–24.

All of these (with the possible exception of the 562 and 565, which were still *preliminary* designs at this writing) may be obtained on special order from the manufacturer. In addition, the major mail-order houses catering to the industrial electronics trade may be able to obtain them although no catalog available to us lists Signetics as one of the lines carried in stock (the firm deals primarily with the original-equipment-manufacturer market). Inquiries should be addressed to Mr. Seymour and should mention this article.

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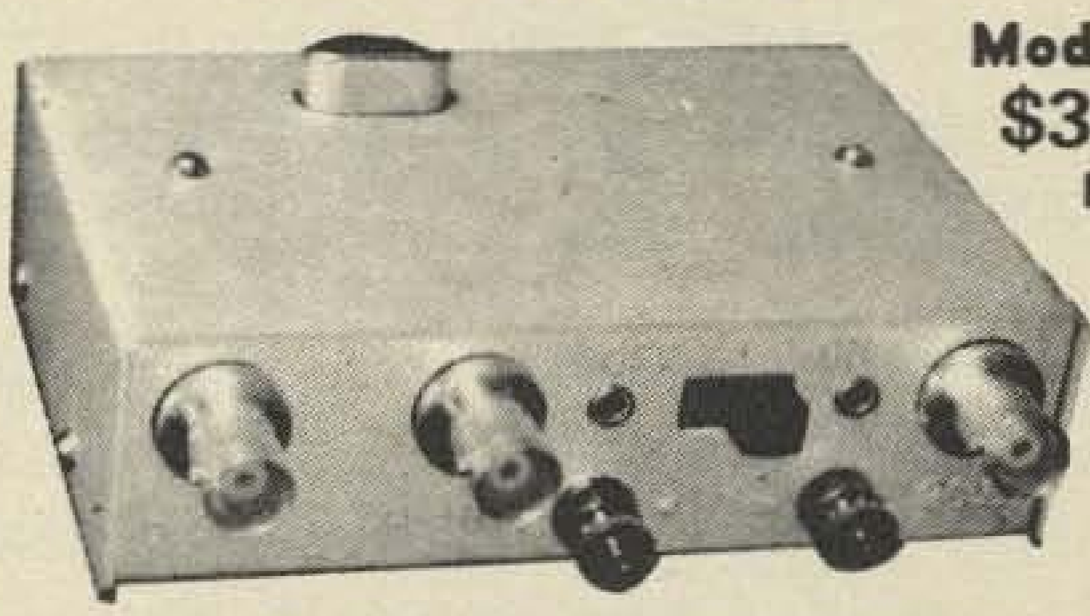

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A LOW COST FUNCTION GENERATOR FOR THE EXPERIMENTER

Most experimenters have audio frequency oscillators, yet their use is severely limited by the lower frequency limit of about 20 Hz in most low-cost units. This limitation exists because of the extremely high impedance necessary to avoid loading the frequency determining network. Until the advent of the field-effect transistor (FET) it was almost impossible to build a low-distortion, low-frequency transistor signal generator. It is still difficult to lower the output frequency significantly without introducing severe distortion.

The unit described in this article has none of the low-frequency limitations of bridge-type oscillators. It generates signals in the range of 4 kHz down to about 10 mHz (that's 10 millihertz, or 0.01 cycle per second!). Such frequencies have many uses, such as generating slow-sweep displays, checking the response of low-frequency filters, and voltage-control applications in electronic music generation, instrumentation, etc. The circuitry is similar to that of a high-priced laboratory instrument known as a "function generator," but by taking advantage of low-cost ICs and nonprecision resistors, it can be built for substantially less than most kit-type audio generators.

Circuitry

Most audio oscillators directly generate a sine wave. Sine-wave oscillators usually are much more critical than other types. The oscillator of Fig. 1 generates a triangular wave which is then shaped into a sine wave using a FET instead of a reactive filter. This renders it insensitive to frequency, enabling the distortion to be constant over the entire range. Due to difficulties in obtaining precise symmetry in FET characteristics, plus nonideal characteristics of the transfer function itself, it is difficult to get the distortion lower than about 1.2%. This is adequate for almost all applications.

Integrated-circuit operational amplifiers (opamps) are used to generate the triangular wave. Unit A2 is connected in a circuit arrangement known as an integrator. Time-determining capacitor C_t is charged at a rate directly proportional to the current fed into pin 2 (the inverting input) of the opamp. Pin 2 is kept at ground potential by feedback through the capacitor, so the current equals the voltage at point V_c divided by the total series resistance, consisting of the resistor on the octave switch and the range trimmers. Thus, it is possible to control the charging

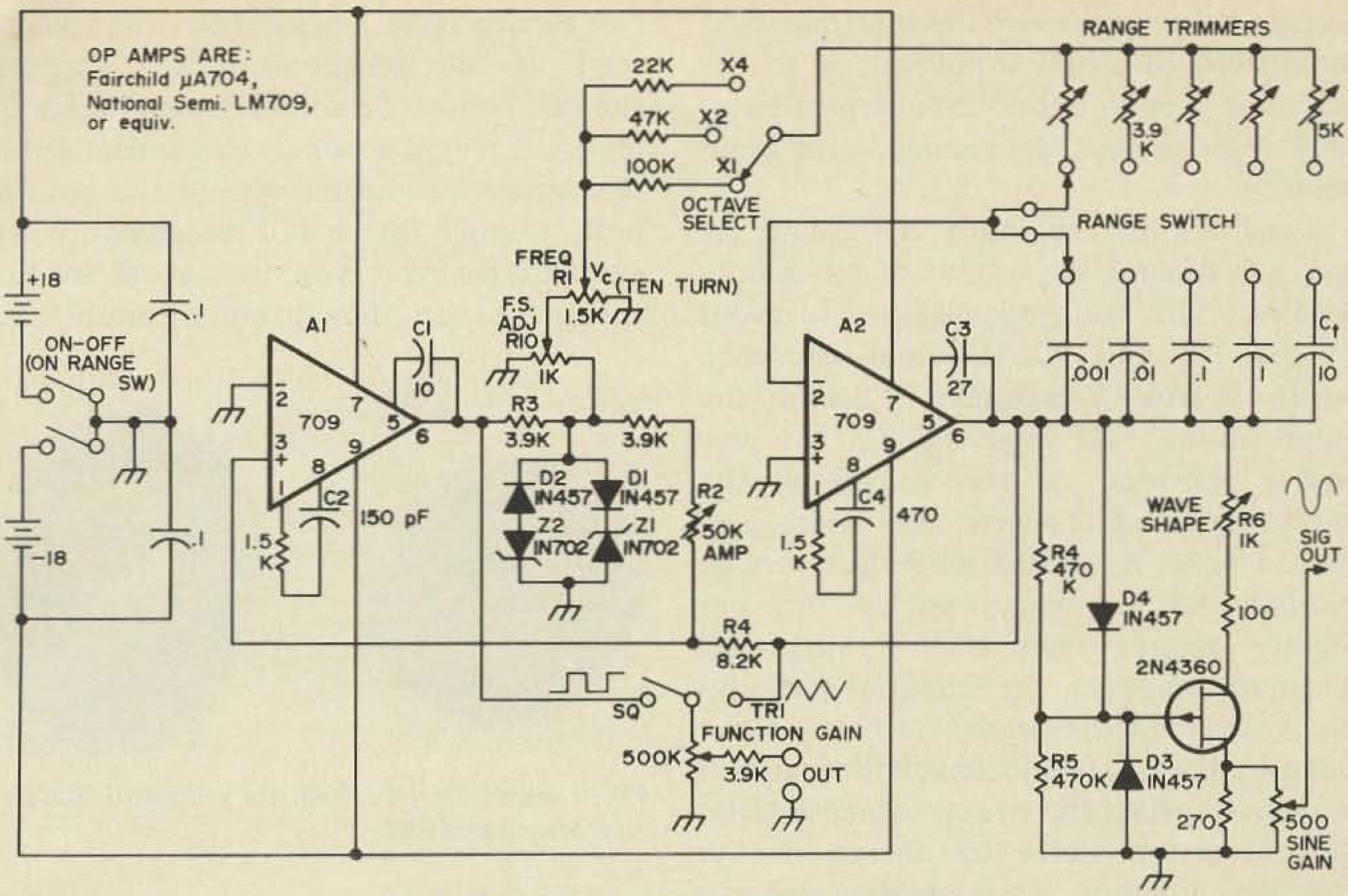
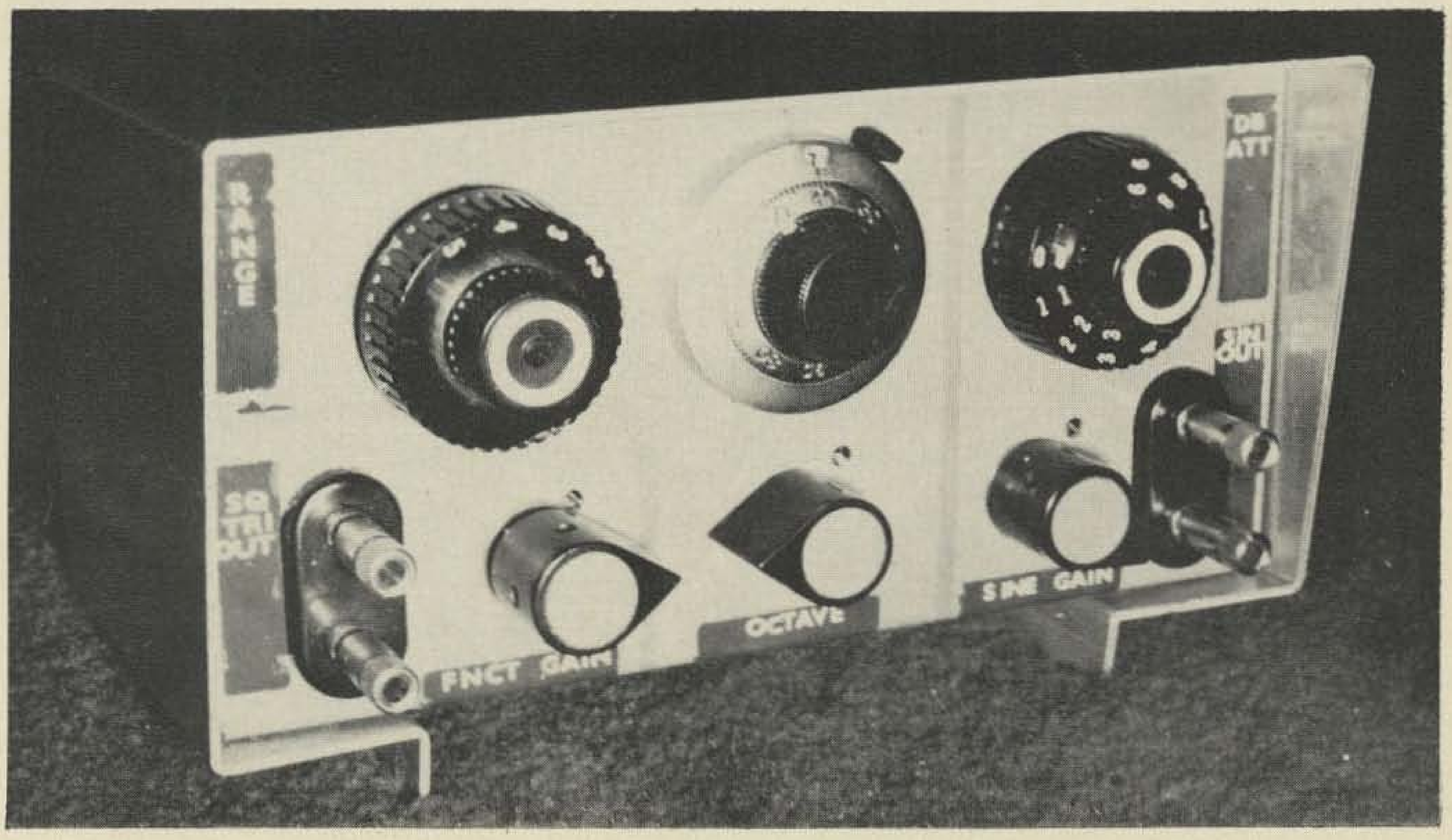


Fig. 1. Function generator schematic diagram.

rate with R1, and the high current capacity vs low leakage current of the opamp allows the charging rate, and hence the frequency, to be varied over a 500-to-1 range, compared to the normal 10-to-1 range for normal capacitance-controlled oscillators.

If a current were just fed into the opamp, the capacitor would continue charging until the limit imposed by the opamp and the power supply voltage was reached. However, A1 is connected to the frequency control pot, and supplies the voltage that is converted into the charging rate by the various resistors. A1 is connected in a positive feedback loop with high hysteresis. The opamp is sensitive to the

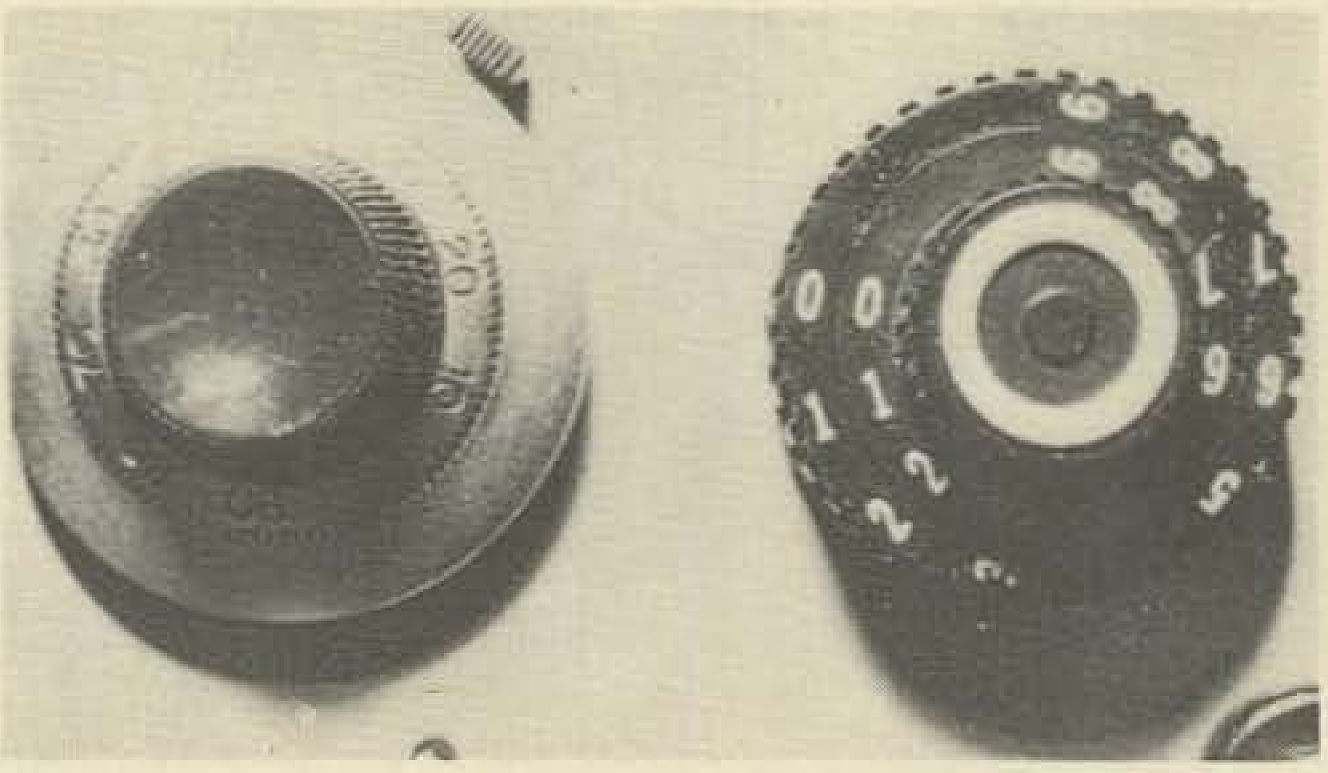


Front panel of function generator.

voltage between the two input terminals. If the difference is only a millivolt or so, the amplifier goes to either its fully positive or fully negative limit, depending on the input polarity.

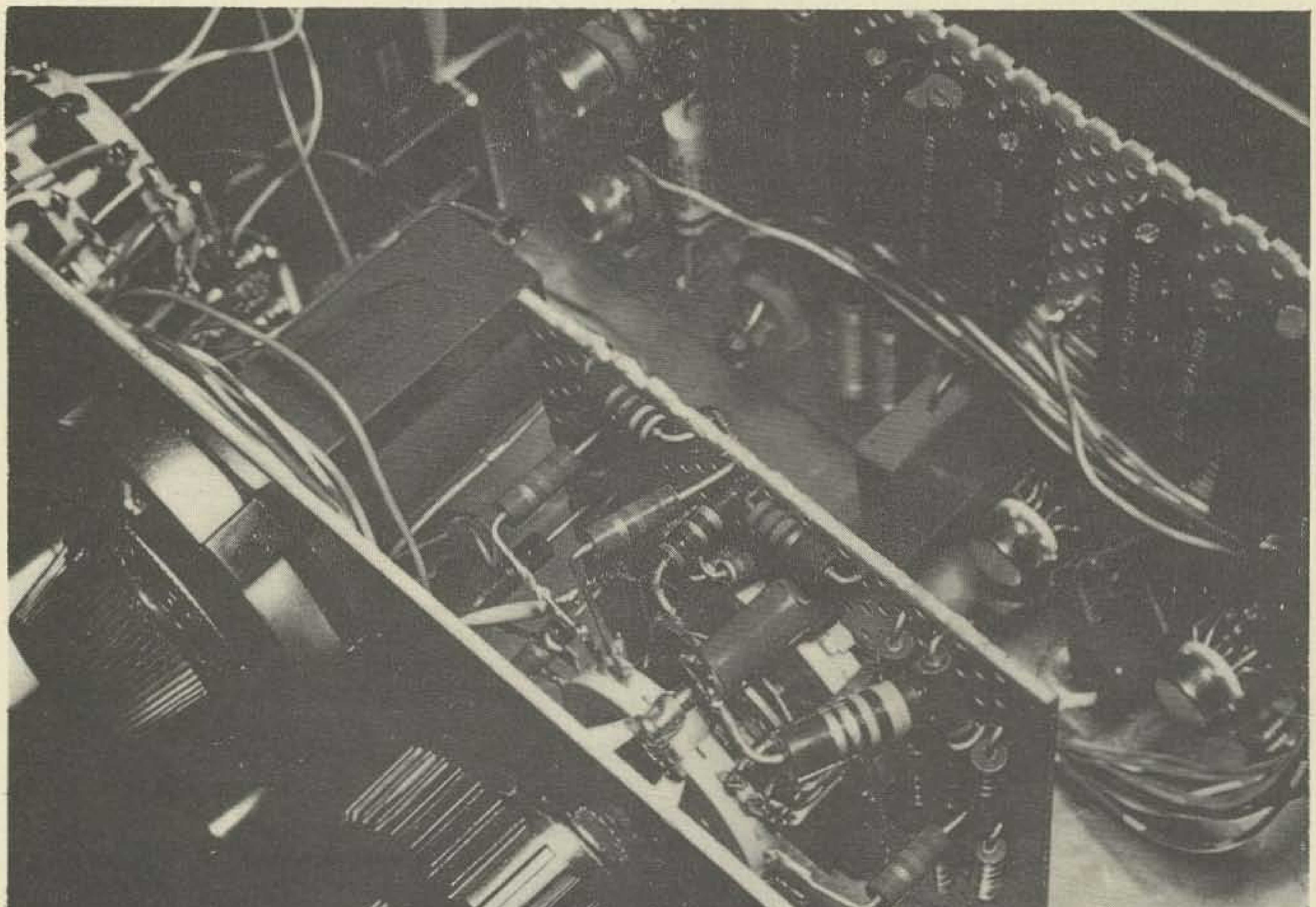
Feedback to the input is through R2 and R4. Assume the output of A1 is fully negative. This voltage is clamped to about 4V by D2 and Z2 (D1 and Z1 when positive). This 4V is connected back to the input through R2 (and the 3.9 kΩ protective resistor). As the voltage at the output of A2 gets increasingly more positive, a point is reached where the current through R4 becomes opposite to and slightly greater than that through R2. When this happens, the amplifier instantly (in a few microseconds) changes state, aided by the positive feedback through R2. Of course, when the opamp changes state, the integrator starts to charge in the opposite direction, thus creating the triangular wave. The zener diodes insure that the wave is highly symmetrical. If your zeners are out of tolerance, or distortion is critical, connecting a small resistor in one leg or the other might help a little.

The sine wave, square wave, and triangle wave are all synchronous and available simultaneously. To conserve panel space on my unit, I used a switch to connect either the square or the triangle to the binding post, though this is not necessary. Whatever arrangement you use, avoid loading the output on the opamp by more than



Front panel view of frequency control dial and step attenuator dial.

about 2 kΩ. It won't harm anything, but the output frequency may change slightly when connecting and disconnecting loads if this precaution isn't observed. It is normally very difficult to measure the



Interior view of unit with step attenuator resistors in front.

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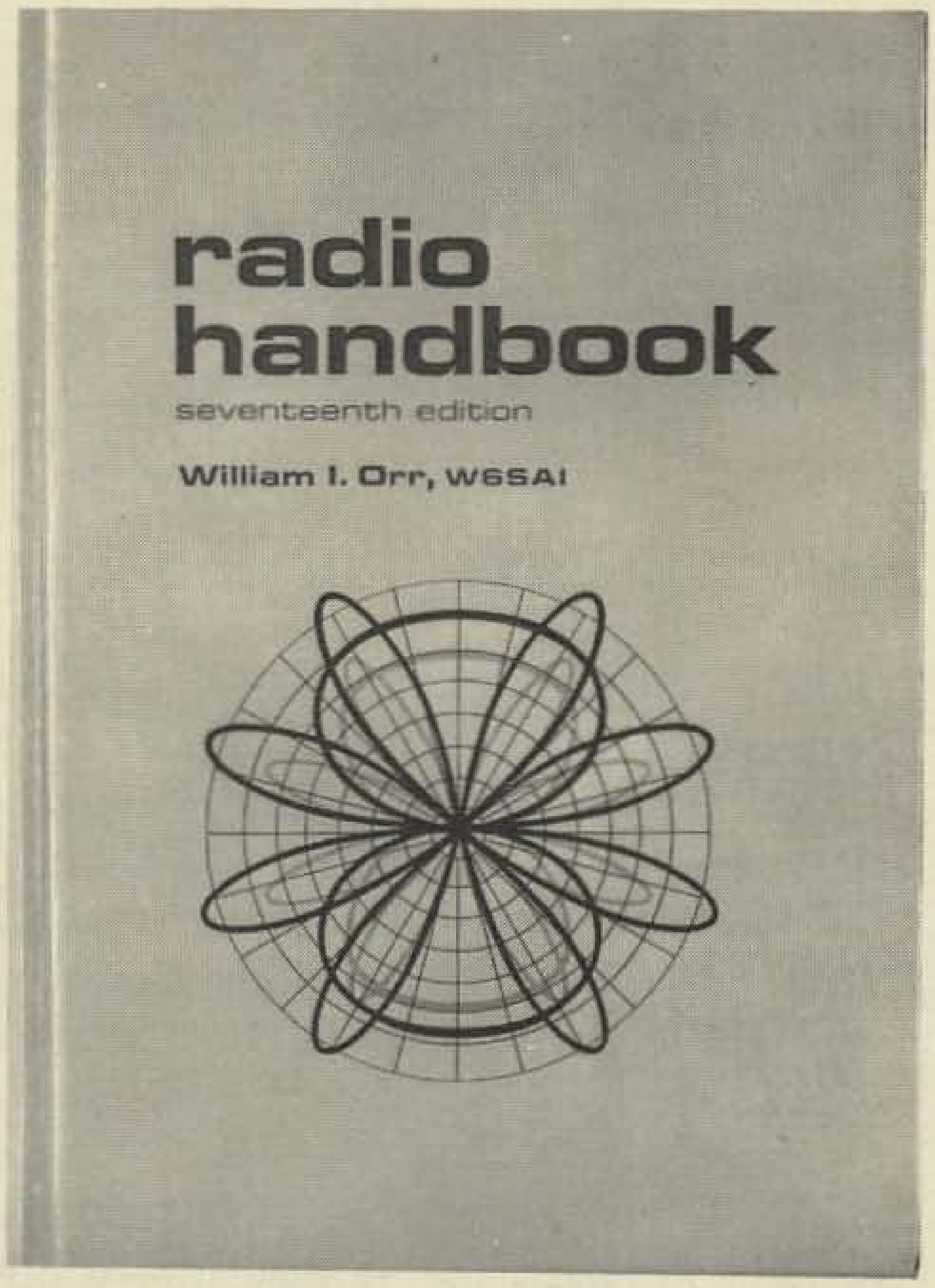

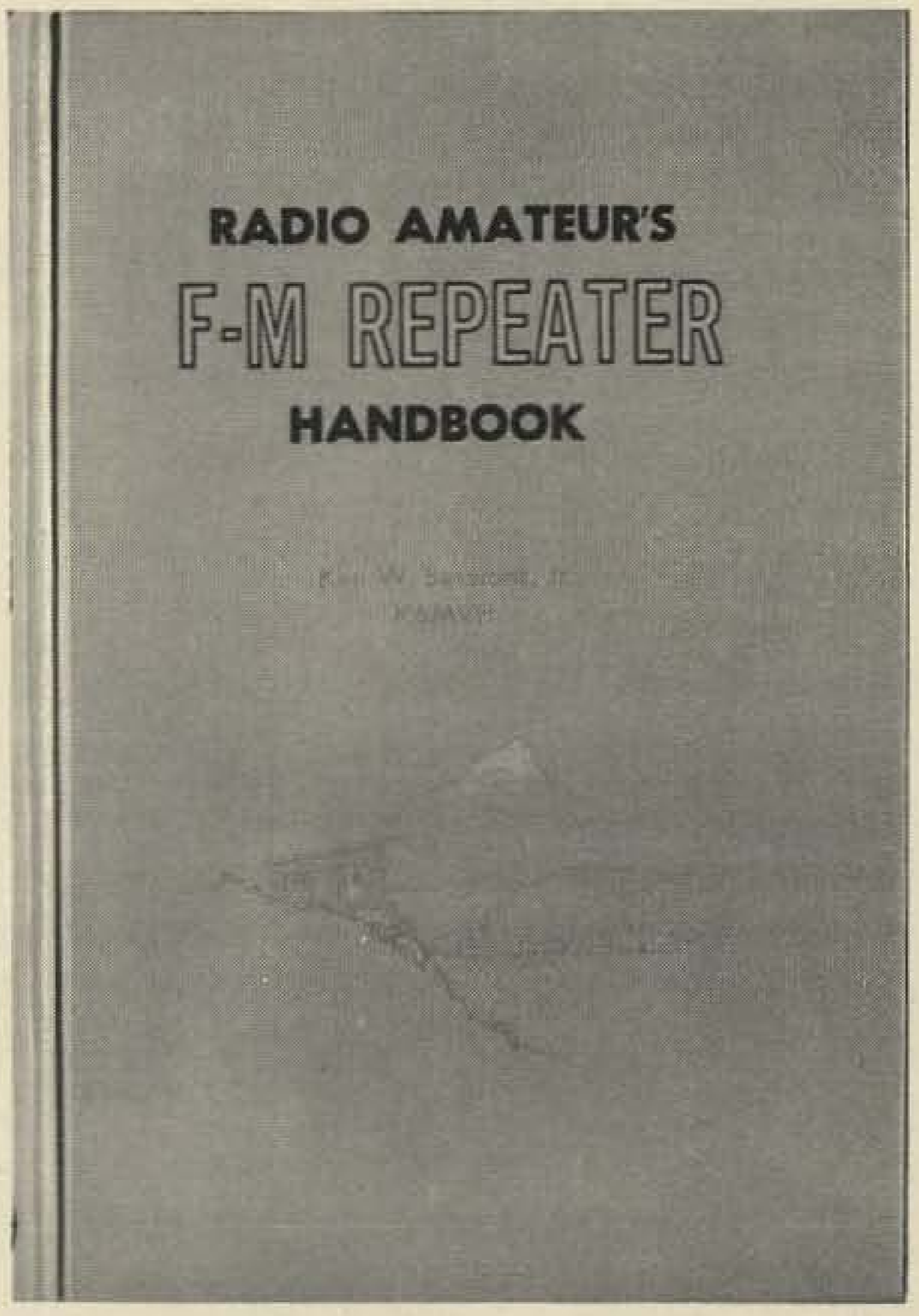

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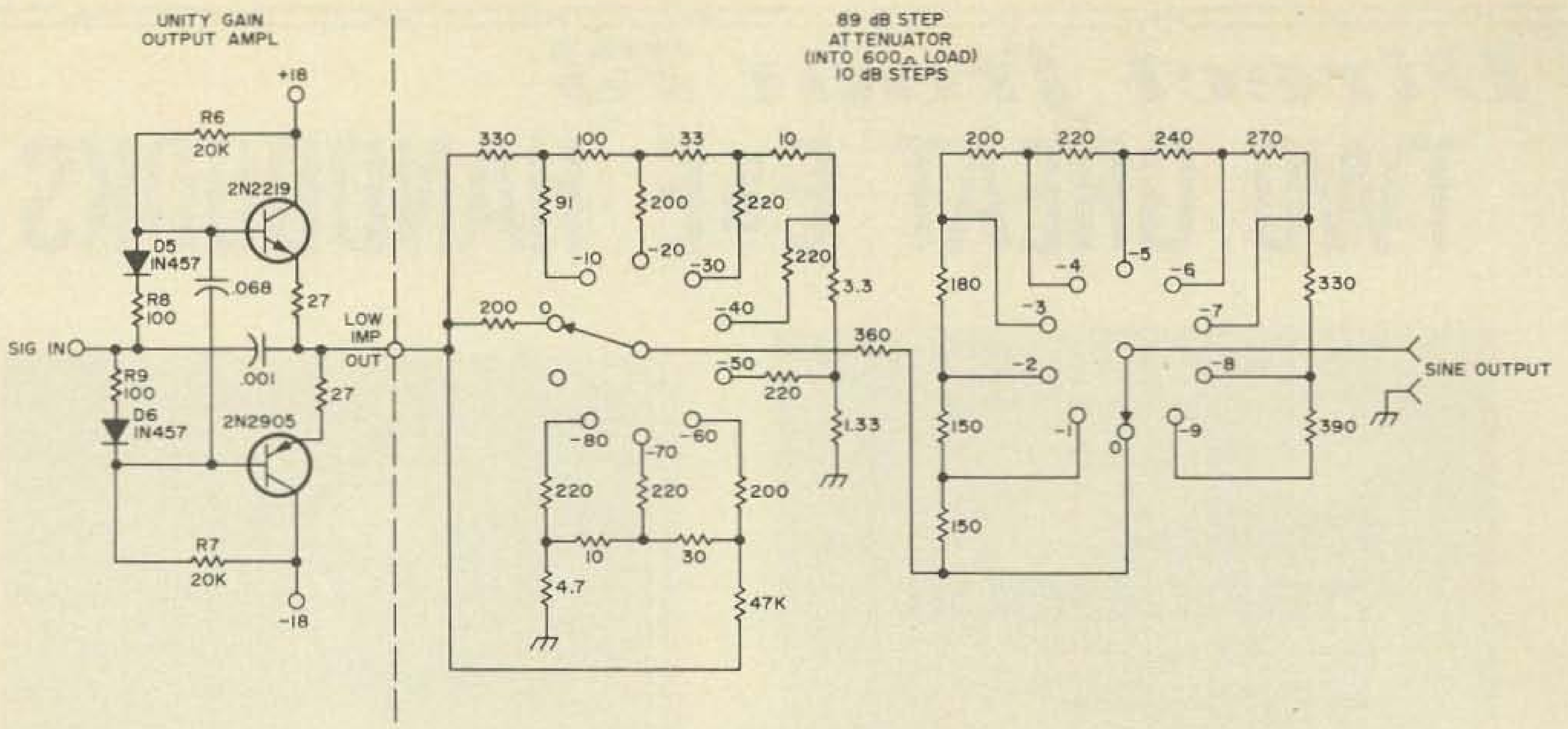


Fig. 2. Output amplifier and attenuator schematic.

frequency of VLF sine waves. Connecting the square wave output to a counter while using the sine output is a great convenience.

The sine wave shaper takes advantage of the symmetry of the source and drain with respect to the gate of the 2N4360 J-FET. (This unit was chosen primarily for its very low cost, as well as its relatively high pinchoff voltage which gives a greater output voltage.) The output of A2 varies symmetrically about ground, and as the absolute value of the voltage increases, the FET resistance also increases due to the gate bias. Incidentally, note that the power to drive the FET circuit is supplied directly by the opamp output. Proper bias polarity is insured by D3 and D4.

Since the output is symmetrical about ground, no coupling capacitors are necessary. It would be hopelessly unwieldy to use one for 0.01 Hz anyway. The output amplifier is designed for unity gain with no voltage offset. Simplicity is achieved through the use of complementary transistors. The output impedance is under 100Ω. Resistors R6, R7, R8, R9, and diodes D5 and D6 are the bias network, which eliminates crossover distortion in the amplifier.

If you plan to use the equipment for checking professional audio equipment, you might desire to add the attenuator shown in Fig. 2. It provides 89 dB of attenuation into a 600Ω load. Two concentric single-pole, 10-position switches break the 89 dB into 1 dB steps.

To simplify the attenuator design and allow the use of standard resistors with 5% tolerance, an unusual circuit was used. The 10 dB steps are provided by a constant-impedance (200Ω) "T" attenuator, and the single dB steps are provided by switching in series resistors. Thus, the attenuator is not of a constant-impedance design, although the voltage into a 600Ω load conforms to the proper setting.

If you are using a high-impedance load, the output should be bridged with a 600Ω resistor. A low-impedance load will exaggerate the effect of the 1 dB step switch.

I emphasize that this whole assembly, while desirable, is purely optional.

Adjustment

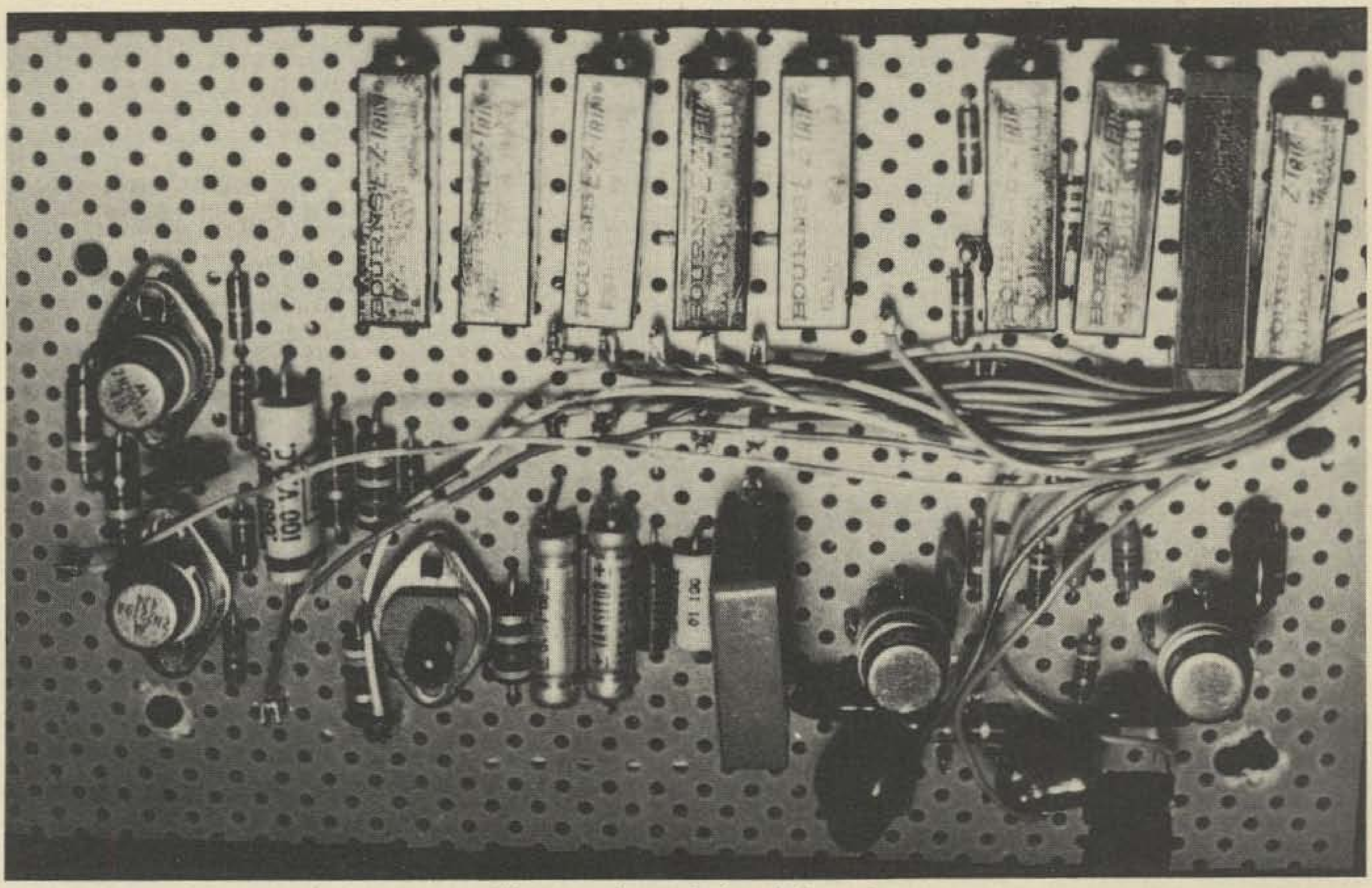
As you can see from the photograph, the frequency control is a 100 turn precision potentiometer. These are readily available for a couple of dollars in the surplus market. Using one, it is possible to calibrate the unit so that for the top 900 divisions, the output frequency is correct to within 1%. As the octave select switch is switched to a lower series resistance, the linearity of the frequency control is decreased. The full-scale adjustment pot sets the output frequency to 100 Hz on the range with the .01 μF capacitor when the octave switch is in the X1 position (100 kΩ series resistance). Then the various range adjust pots are set until each range has the appropriate full-scale value: 1 kHz, 100 Hz, 10 Hz, 1 Hz, 0.1 Hz.

Potentiometer R2 is adjusted so that the triangle amplitude is proper for conversion to a sine. This control interacts with the full-scale adjustment pot, so they both may have to be readjusted several times. Waveshape pot R6 is adjusted for symmetry in the top and bottom halves of the sine wave. A scope or harmonic distortion meter is advisable for the above two adjustments, although a reasonable null can be achieved by a musically trained ear, especially if there is an undistorted signal available for comparison.

Construction

The circuitry is noncritical and any convenient layout may be used. Power is provided by four 9V batteries. Do not exceed this voltage as the operational amplifiers are rated for a maximum power supply potential of ±18V. The batteries should be bypassed with 0.1 μF capacitors. If any trouble is encountered with the opamps oscillating at high frequency, it will probably be eliminated by bypassing the power supply pins to ground as close to the IC as possible. If this doesn't work, add capacitance to C1, C2, C3, and C4 a few picofarads at a time until oscillation stops. The values given in the diagram are calculated to work with almost all production opamps, but occasionally one will be near the edge of the specifications and require the extra capacitance.

If you don't need precise frequency calibration or attenuation, substantial cost can be saved by eliminating these features. The range trimmers can also be eliminated (just replace with a short circuit). The octave switch can be replaced with a fixed resistor down to 15 kΩ or so. The output attenuator can be replaced with an ordinary pot; and substitute the 500Ω pot and 470Ω opamp resistor before the amplifier with a 240Ω resistor; and connect the opamp input directly to the FET. The pot must be connected to the amplifier output to attenuate the amplifier noise as well as the signal. Use any convenient pot for the frequency control, and calibrate the dial yourself.



Closeup view of circuit board.

Following these procedures can reduce the cost to under $10 and yet provide you with an oscillator that, in the lower frequency ranges, is better than anything selling for under the price of a laboratory function generator.

. . . WA2IKL ■

CONTROLLING *Repeaters* WITH TONES

by Ken W. Sessions, Jr. K6MVH

A few years ago, an amateur repeater typically consisted of not much more than a transmitter and a receiver, interconnected to operate as a repeater. But a number of factors have served to bring about a trend toward limited control of the repeater through the use of audio tones transmitted on the repeater's input frequency. When two repeaters are close enough to one another so that a user station triggers both repeaters when he attempts to use but one, a tone system is called for. When a group of amateurs band together to put up a repeater for the exclusive use of material supporters, again tones are required. When the repeater input frequency is commonly used for a simple channel (point-to-point, or direct), a tone system is the only way to insure that the repeater is only triggered when it is actually being used by one of the stations on the frequency.

Today, the toned repeater is at least as common as the straight "carrier-operated" repeater, and the trend towards tone control is certain to increase from here on out.

The three most common methods of tone control for amateur repeaters are, in order of popularity, "tone burst," "whistle-on," and "continuous-tone-carrier-squelch." The first two systems employ the use of a relatively high-pitched audio tone of short duration. The latter employs a continuously transmitted very-low-frequency "subaudible" tone of a specific and usually quite critical frequency. Each system has advantages the others do not share. It is up to the repeater designers to look at the merits of the three systems, then adopt the one that best meets their particular needs.

A tone-burst system installed in a repeater will require each user to transmit a short tone "burst" each time he wants to communicate through the repeater. The only practical method of utilization in such systems is for each user to install a tone oscillator in each of his transmitters, along with a simple timer to limit the duration of each tone burst, and a method for automatically keying the oscillator each time the transmitter push-to-talk circuit is actuated. Each user should also install a switch so that he can take the tone oscillator out of the circuit when he is not operating through the repeater.

But on the plus side, the tone-burst system is the simplest of all the systems to install at the repeater; it will consist of nothing more than a single relay and a timer to limit length of each transmission (assuming that a tone decoder is already installed at the repeater site).

The whistle-on system is the nicest from the standpoint of the users, who must possess no oscillators other than the one with which they were born. A simple brief whistle will turn on the repeater, and the repeater will operate from that point on in a purely carrier-operated manner. After a specified time period of inactivity (say, no incoming repeater signals for five minutes), the repeater will shut down. To turn it on again, the next user will have to command it with another orally produced whistle. As with the tone-burst system, the whistle-on approach includes a transmission-limiting timer of a minute-and-a-half or so.

The whistle-on concept offers the most in terms of flexibility, but it requires two timers and a relay (in addition to the broad tone decoder). Interconnection, however, is quite simple.

The third approach, continuous-tone-carrier-squelch (most frequently referred to by Motorola's tradename of *PL*, for "Private Line"), is the least flexible, the most difficult to implement, and the most critical with respect to audio stability. It is also the most secure of the three, which is one of the reasons many amateurs elect to use this system for their "closed" repeaters.

There is little complexity at the repeater site with a PL system, since nothing other than the decoder itself is actually required, even though most amateurs like to add a delayed-dropout relay to avoid "chopping." But the problems faced by the users are manifold. Here, every transmitter that is intended to be used with the system must be equipped with highly stable low-frequency tone generators. And, unless great care is taken in the setup of all the stations, the repeater in use will sound like a bunch of stations who use unfiltered power supplies. A good PL system should be subaudible, but amateur setups – commercials, too, for that matter – seldom are.

Basic Control Logic

Once the type of tone access approach is chosen, the repeater should be set up to provide the widest possible number of logic outputs, which can be used for an almost endless array of later control functions. The tone decoder, for example, should drive a relay to provide voltage and ground outputs when the proper incoming tone is sensed. And the carrier-operated relay should likewise be set up to drive a multicontact, heavy-duty "slave" that provides voltage and ground output signals for both the *signal* and the *no signal* states. These logic signals will prove invaluable as additional control functions are implemented.

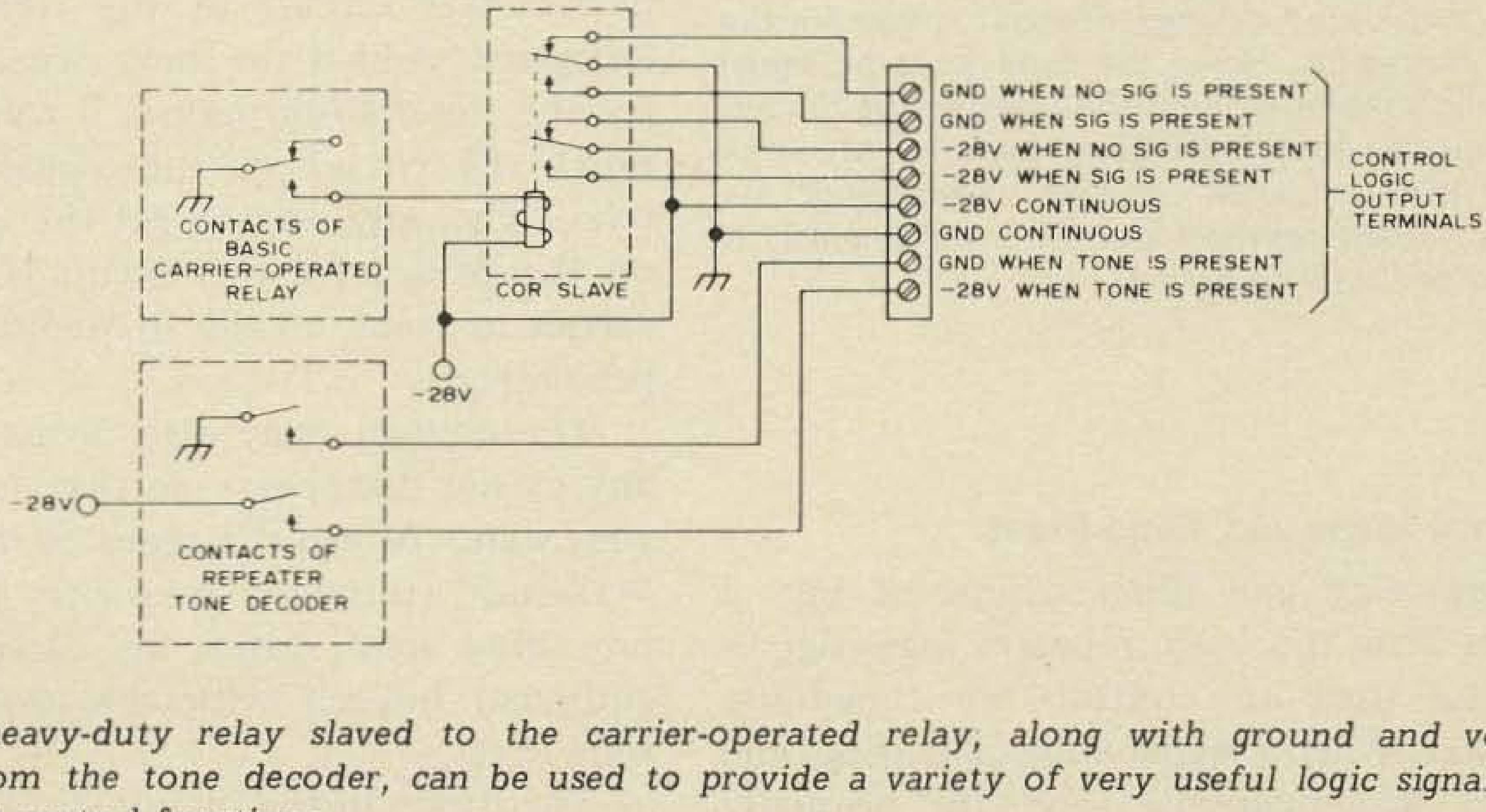


Fig. 1. A heavy-duty relay slaved to the carrier-operated relay, along with ground and voltage outputs from the tone decoder, can be used to provide a variety of very useful logic signals for all repeater control functions.

The circuit of Fig. 1 shows how the logic signals are obtained and what they are. The control circuits described here and in other "repeater control" articles will always require at least some of the logic signals available on the terminal board.

Control Logic and PL

A good example of how the logic signals can be used appears in Fig. 2, which is the heart of a PL control system. The coil of a delayed-dropout relay is fed with the ground output of the tone decoder and the voltage output from the carrier-operated relay. If the tone is erratic, the relay stays keyed because of the timer's delay of a half-second or so. But, since the carrier-operated relay ground output signal is used to key the transmitter push-to-talk circuit directly (through the contacts of the delay relay), any loss of signal will cause the repeater to shut down immediately. Thus, there is no "delayed squelch" arrangement, yet the users are protected from fluttering of the repeater that might be caused by borderline settings of their tone units.

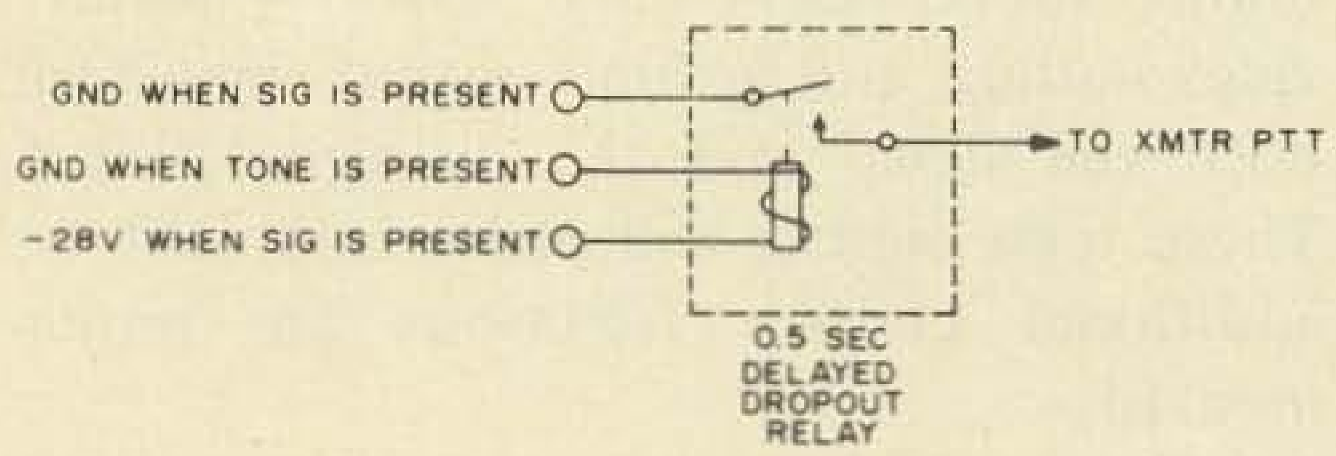


Fig. 2. There are many methods for keying continuous-tone-carrier-squelch (PL) systems, but those employing delayed dropout relays are the most successful. Here, the tone and the signal must be present to hold the repeater on the air. Momentary tone variations because of weak signal will not cause "cycling" because of the delay, but the repeater will drop out instantly if the carrier itself drops out.

Control Logic and Tone-Burst

The relay and timer circuit of Fig. 3 shows how the basic repeater logic signals can be used to control the tone-burst repeater. When a signal appears without the proper accompanying tone, the normally open contacts of the repeater control relay keep the COR ground signal from being fed to the repeater push-to-talk circuitry. When the correct tone appears, however, a ground signal from the tone decoder energizes the coil of the repeater control relay (whose voltage is supplied through the normally closed contacts of a 1.5-minute timer). The control relay pulls in and is latched by the COR ground signal now being supplied through the relay's own contacts.

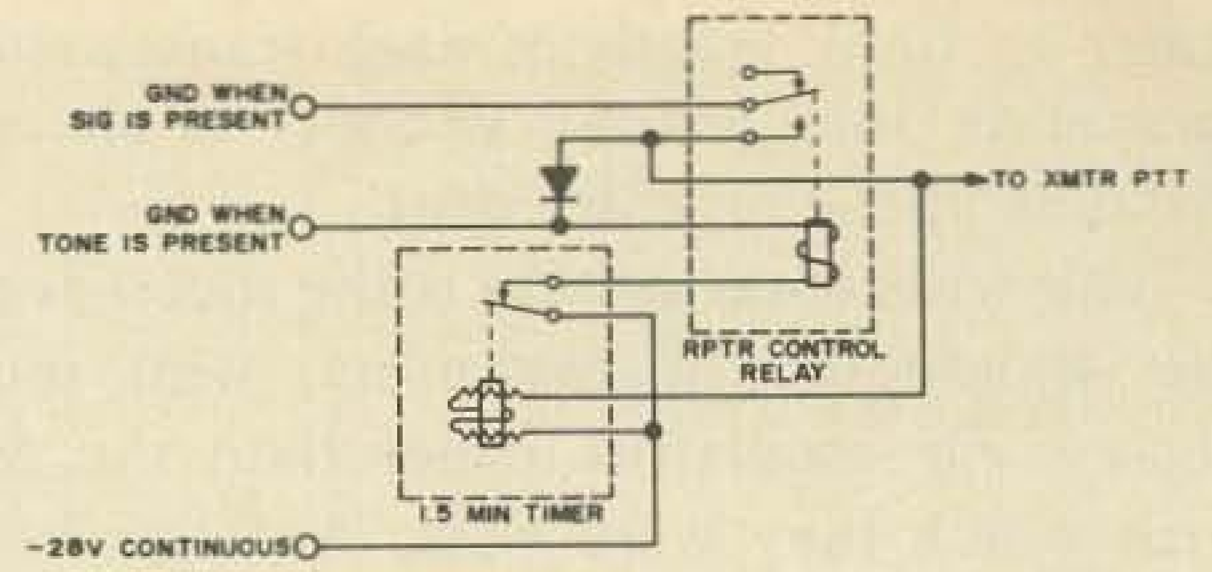


Fig. 3. Tone-burst repeaters can be set up with nothing more than a relay and a timer if the decoder and COR logic signals are available. Here, a short tone burst will energize the control relay, which latches as long as a carrier stays on the input. If the carrier stays on more than 1.5 minutes, the repeater will go off the air and a new tone will be required. Each transmission must be accompanied by the proper tone burst.

Even though the tone burst is short, the repeater control relay will keep the transmitter on the air as long as a signal stays on the input frequency – unless that time period happened to exceed a minute-and-a-half.

The timer is keyed at the same time the push-to-talk circuit of the transmitter is energized. And if the same signal is present for the timer's full period, it will pull in to break the circuit on the repeater control relay. The only way to get the transmitter on the air again if this occurs is for a new carrier to come on the frequency with the proper tone.

The control relay also drops out when any carrier disappears, so that each station who wants to use the repeater must either "tail-end" (seize the frequency before the preceding user drops his carrier) or be equipped himself with the proper access tone burst.

The diode in the circuit, by the way, is to keep the tone decoder ground signal from being overworked. Without the diode, the decoder ground signal would have to key the transmitter push-to-talk and the transmission-limiting timer. With the diode, the tone decoder ground can only trigger the repeater control relay.

repeater will shut down. Another whistle must be sent to bring the repeater on again.

As with the tone-burst system, a timer is typically employed to limit the length of transmissions going through the repeater. Figure 4 shows the circuit and the logic

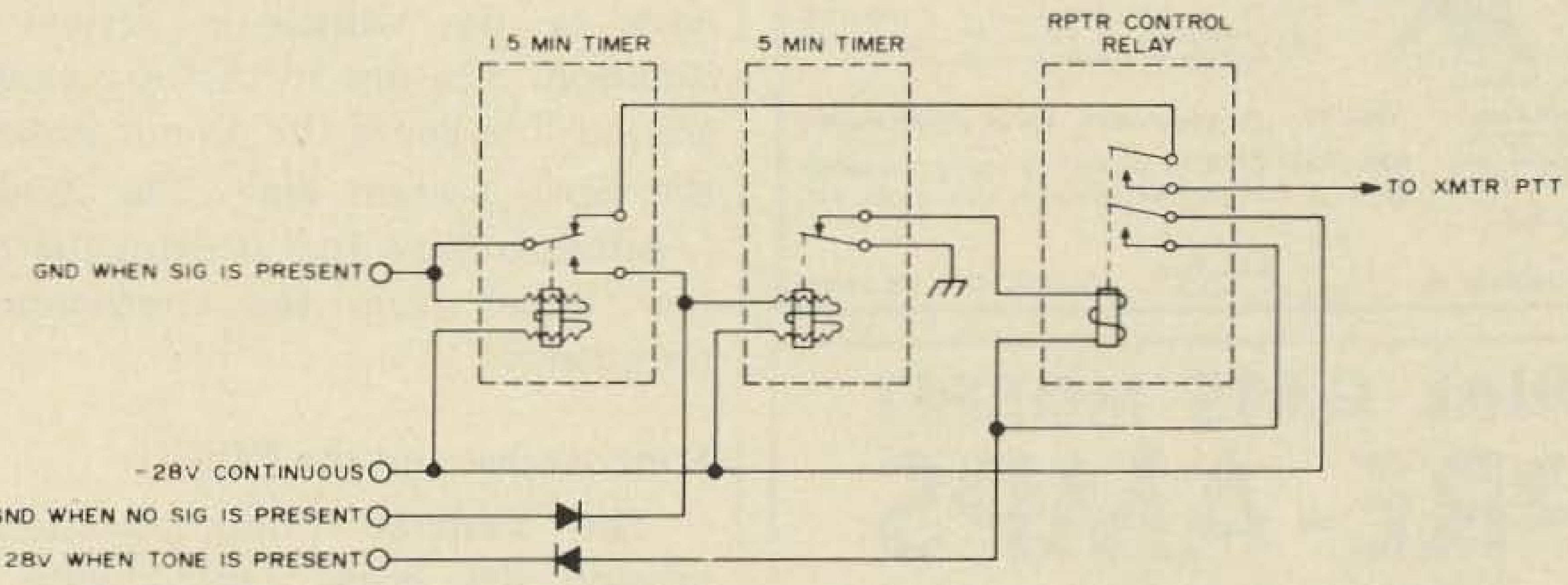


Fig. 4. The complete whistle-on control system contains two timers and an ordinary relay. If a carrier stays on for more than 1.5 minutes, the push-to-talk circuit is disconnected. If the carrier stays on 6.5 minutes, the repeater shuts down and must be whistled on again. Also, if nobody uses the repeater for 5 minutes, shutdown will occur.

Control Logic and Whistle-On

Not many people really understand the "whistle-on" approach. Some amateurs seem to think that if they can whistle to bring a repeater on the air, that process constitutes a whistle-on system. However, in spite of the fact that many tone-burst systems can be accessed by a whistle, a true whistle-on system is one that has been designed for access by whistling. And to be convenient, no whistle approach can require the users to whistle each time they transmit.

A whistle-on repeater may stay off the air for long periods. Stations can transmit as much as they want on the input frequency, but no repeater will be around to assist in their communications unless one of the users decides to call up the repeater by uttering a brief whistle. When the tone decoder at the repeater senses the presence of the whistle, on comes the repeater, *as a conventional carrier-operated system as long as the repeater is active with users*.

When the users all drift away, and the repeater becomes inactive, the repeater starts counting time. After a specified period, usually five minutes or so, the required to produce a sound whistle-on repeater system.

Normally (when the repeater has not been whistled on), incoming signals cannot be fed to the push-to-talk because the COR ground signal goes no further than the normally open contacts of the repeater control relay. When the whistle is sensed, however, decoder voltage causes the control relay to pull in (and latch). Now all signals, tone equipped or not, will be repeated.

When a single transmission exceeds 1.5 minutes, the COR ground signal causes the timer to pull in and disconnect the push-to-talk. If the user was simply longwinded, he'll quit transmitting in a minute or two and the system can go right back into normal operation, with no new whistle required. But if the problem is more serious than a longwinded ragchewer, the whole repeater will shut down completely in five more minutes. The COR ground is rerouted after the first minute-and-a-half to the five-minute timer, which causes de-energization of the repeater control relay at the end of its period.

The five-minute timer is also used to shut down the system when nobody is using the repeater. A ground signal from normally closed contacts on the COR slave relay completes the circuit on the timer coil. This "double duty" provides for an extremely safe and self-controlling repeater system.

As with the tone-burst circuit, the diodes in the whistle-on system are for isolation. The one in the *no signal present* ground line keeps the circuit isolated from the *signal present* logic. The diode in the negative voltage line isolates the *tone present* signal from the *continuous −28V* terminal.

Tone Access and the FCC

The Federal Communications Commission has been riddled with requests from amateurs seeking to get a relaxation in the rules governing remote control and general operation of repeaters. The indications are quite strong that the relaxation may come, but not until repeater designers and builders prove beyond doubt that effective, failsafe, and adequate measures for autocontrol and subcontrol (tone access) can be demonstrated.

The need for monitoring from a fixed UHF facility has been challenged by amateurs and defended by the FCC. Commission spokesmen say they will not even consider allowing unmonitored repeaters, or control from a mobile, until a positive means can be shown for providing certain, reliable control under all operating conditions. Tone-access repeaters with backup timers for passive control are a giant step toward meeting this goal.

Ed. Note. A series of three articles describing tone generators and decoders appeared in 73 Magazine, Feb 1970. The series includes "Encoders for Subaudible, Tone-Burst, or Whistle-On Use," by John Gallegos (W6ZCL), "Tone Decoders for Remote Switching Applications," by Ken Sessions (K6MVH), and "Setting Up the Tone-Burst System," by Les Cobb (W6TEE). The reader is referred to this series for encoder and decoder circuits and for installing tone units into user transmitters.

... K6MVH ■

SIMPLE REGULATED POWER SOURCE FOR ICs

Integrated circuits and some transistor units require low supply voltages at relatively high currents. While dry cells can meet the requirement temporarily, serious work and finished units are conveniently fed with line-operated supplies. The usual answer is a transistor regulated supply often more complex than the device it feeds.

The circuit shown in Fig. 1 was designed to supply an IC logic section of a business machine. It would make a compact low-cost supply for an IC keyer or for general experimental work.

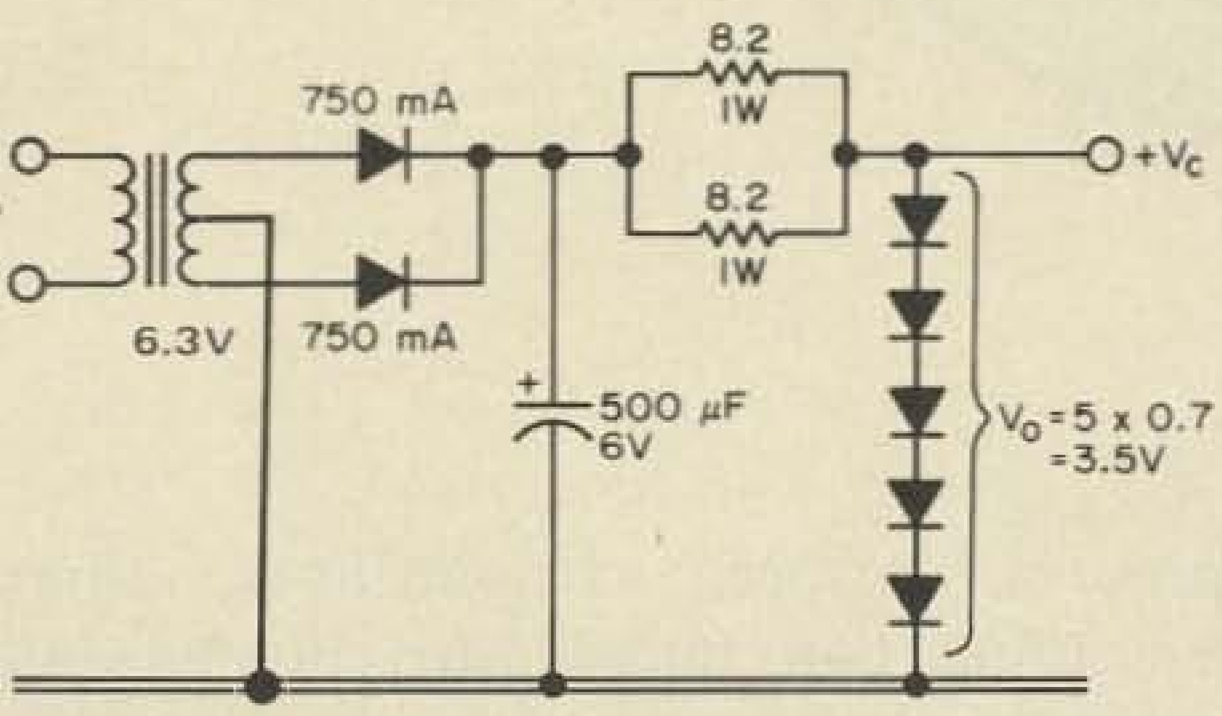
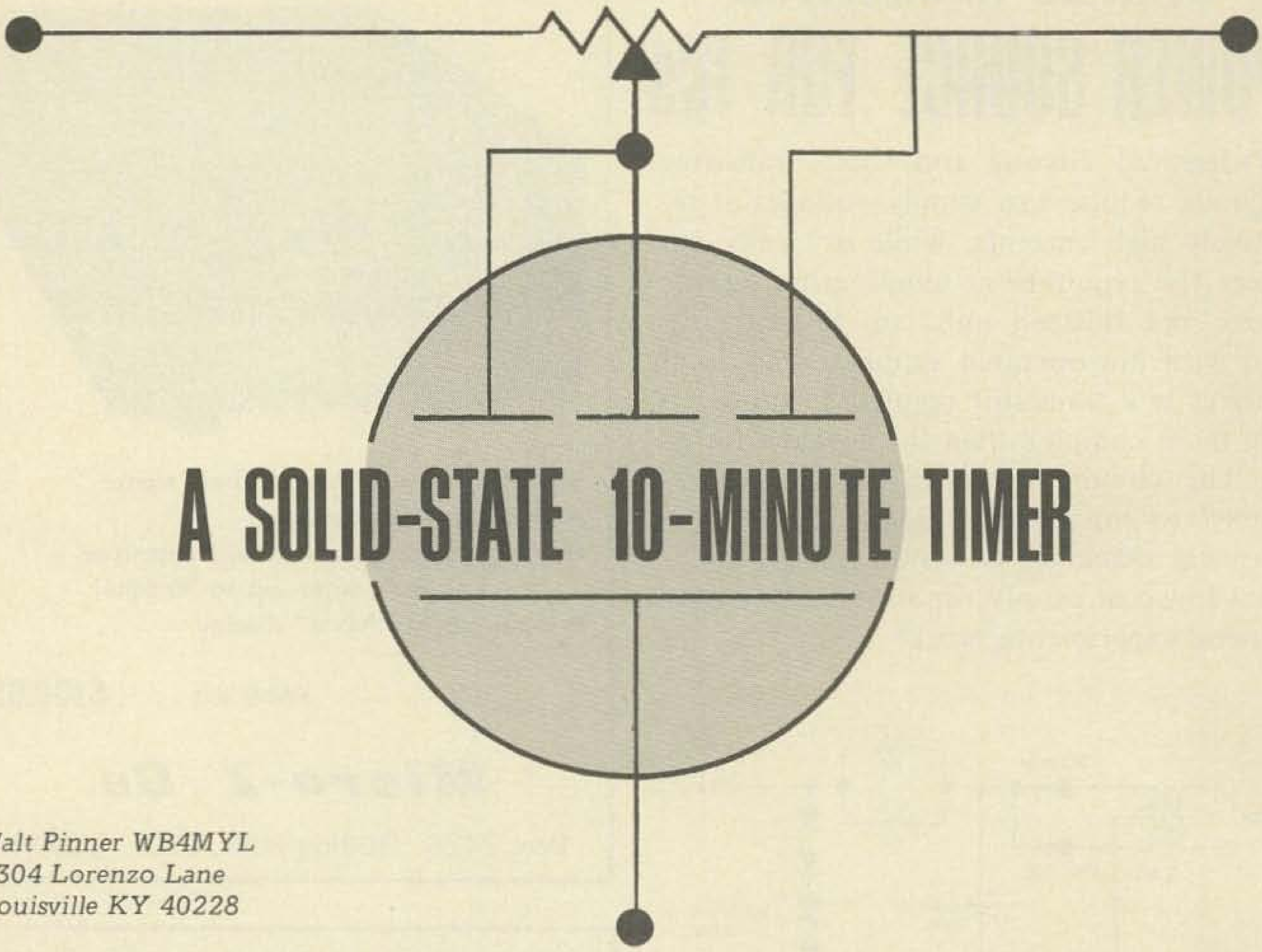


Fig. 1. Simple regulated power source for IC s.

Basically, it takes advantage of the 700 mV forward voltage drop of silicon diodes which varies only slightly with current change. A little time spent selecting individual diodes can provide a regulator for the exact voltage desired, including those values for which standard zeners are not available. Best of all, it can be assembled from parts commonly lying idle, thus freeing the regular bench supply for more demanding work.

The 4.1Ω limiting resistance provides short-circuit protection for the 750 mA rectifiers, and is a necessary part of the filter circuit. A load current variation from 0 to 50 mA causes a supply drop of just 1.65%. To improve regulation at higher currents, increase the size of the filter capacitor.

Edward L. Raub, Jr. W1RAN



A SOLID-STATE 10-MINUTE TIMER

Walt Pinner WB4MYL
7304 Lorenzo Lane
Louisville KY 40228

This 10-minute solid-state station timer is a simple economical, one-evening project whose application is only governed by your imagination. An indicator is illuminated by a *set* button and burns for 10 minutes before extinguishing, thereby reminding you longwinded ragchewers or break-in operators to identify as required by the FCC. The unit, made up of 11 components, is installed inside my SB-100 transceiver with the indicator lamp located behind the main tuning dial, where it is readily visible (eliminating the need for hole drilling).

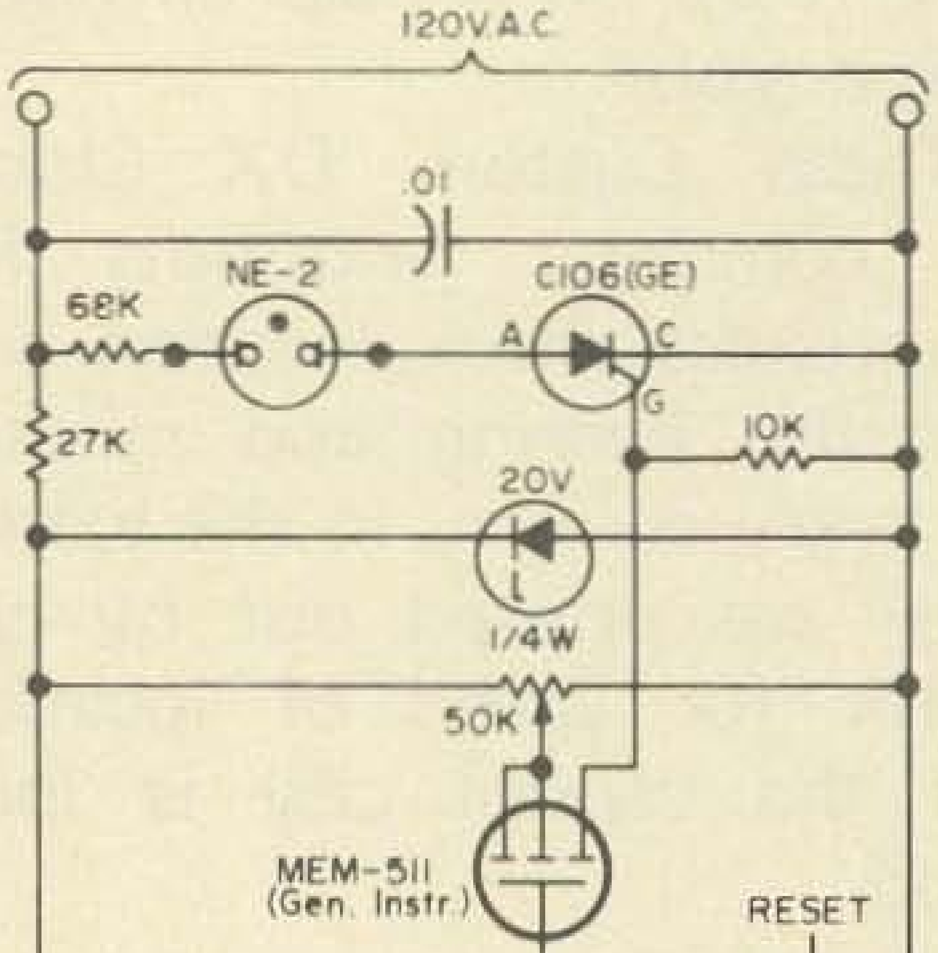


Fig. 1. Schematic diagram of the MOSFET 10-minute timer.

As shown in the circuit diagram (Fig. 1), the heart of the unit is a MOSFET which gates an inexpensive SCR to turn on an indicator lamp (or, if you prefer, energize a relay). Voltage pulses are applied to the transistor and the RC timing circuit, 100 MΩ low-leakage diode, and a 3 μF 100V capacitor.

When 6V appears at the capacitor, the FET is turned off, turning off the SCR and the indicator lamp. Pressing the *set* switch discharges the capacitor, recycling the circuit for an additional 10 minutes.

Because the circuit is line-operated, all components should be isolated from the chassis. In view of the high impedances involved do not attempt to measure voltages, as any but the most sophisticated test equipment will load the circuit.

Caution . . . The FET is supplied with a shorting wire around its leads; this should remain in place until the transistor is soldered in the circuit.

Precise timing is adjusted with the 50 kΩ pot, which will compensate for component tolerances. Any neon panel indicator with a built-in resistor can be used in place of the NE-2 and 68 kΩ resistor. Color the bulb to contrast with existing panel lighting. Should you wish to power other dc loads up to 2A merely substitute your choice for the lamp. For loads in excess of 2A, the NE-2 may be replaced by a 115V ac relay with a series 600Ω 10W resistor and filter (Fig. 2).

The 600Ω resistor limits the direct current through the ac relay to a safe level, and the 20 µF capacitor insures that the relay will remain on during the half-cycle the SCR is off. The reset switch may be any unused contacts on your rig, such as spare positions on your 100 kHz calibrator switch. It may also be convenient to replace a control with one having a pull switch, thus eliminating the need for hole-

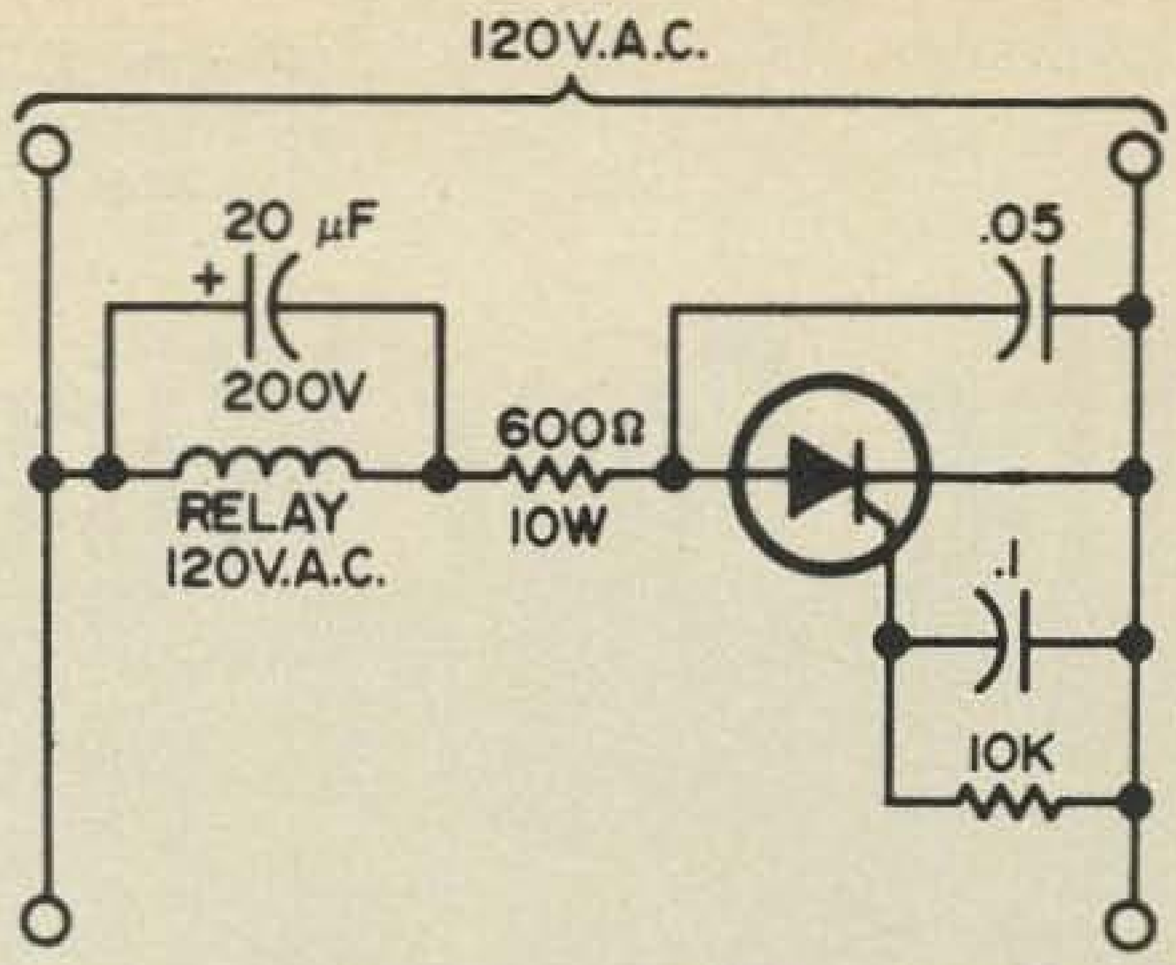


Fig. 2. A relay and associated filter network may be used as shown for switching loads in excess of 2A.

drilling should you wish to preserve the original appearance of your equipment.

Wiring is not critical and a circuit board (full size) is shown Fig. 3. After soldering, it is suggested that all connections on the board be cleaned with a solvent such as nail polish remover to eliminate leakage via flux, etc. The zener and low-leakage diode were obtained from surplus boards. The SCR is not critical, and any type with 120V ratings that will trigger at 0.8V is acceptable.

. . . WB4MYL ■

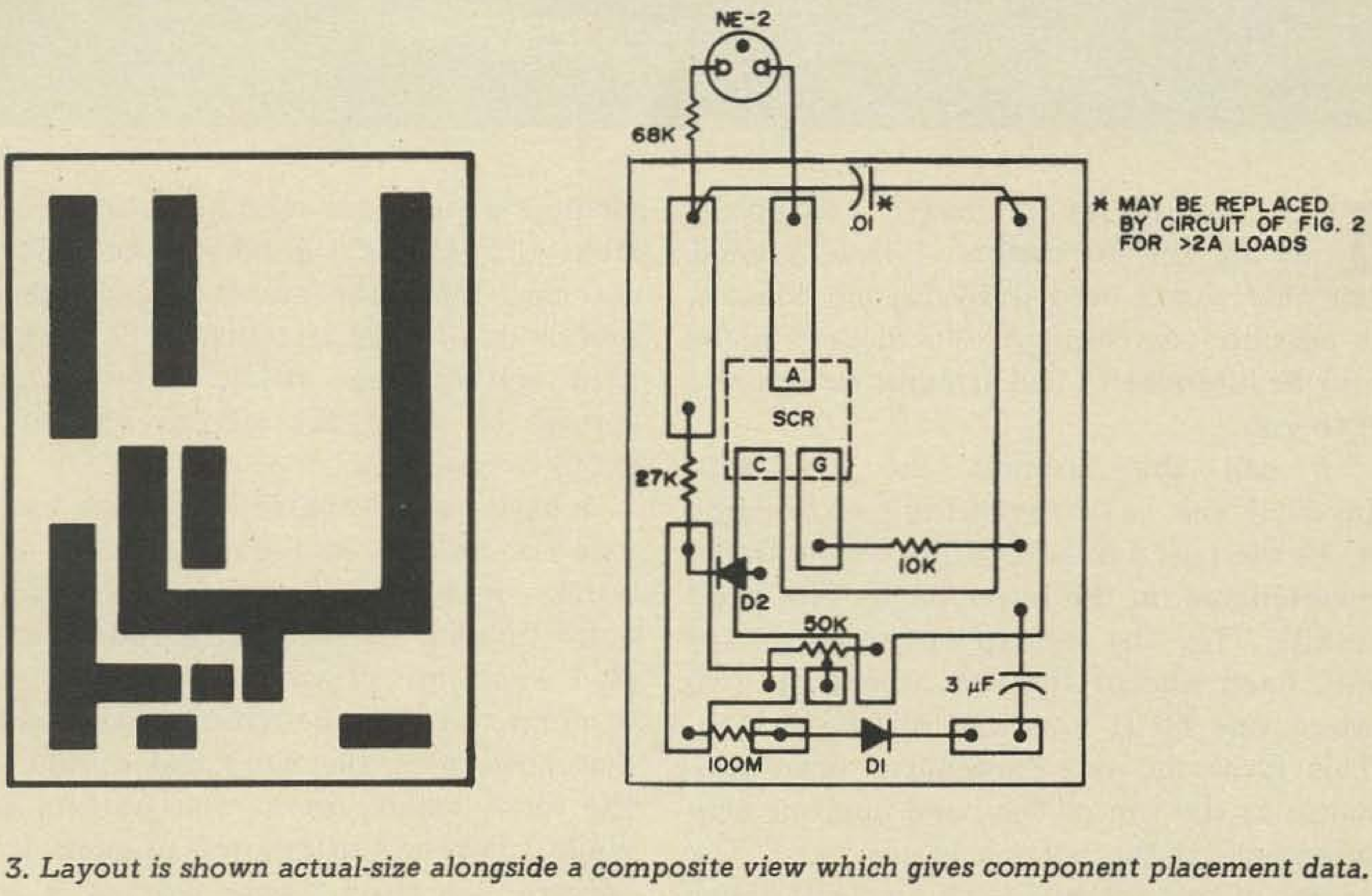
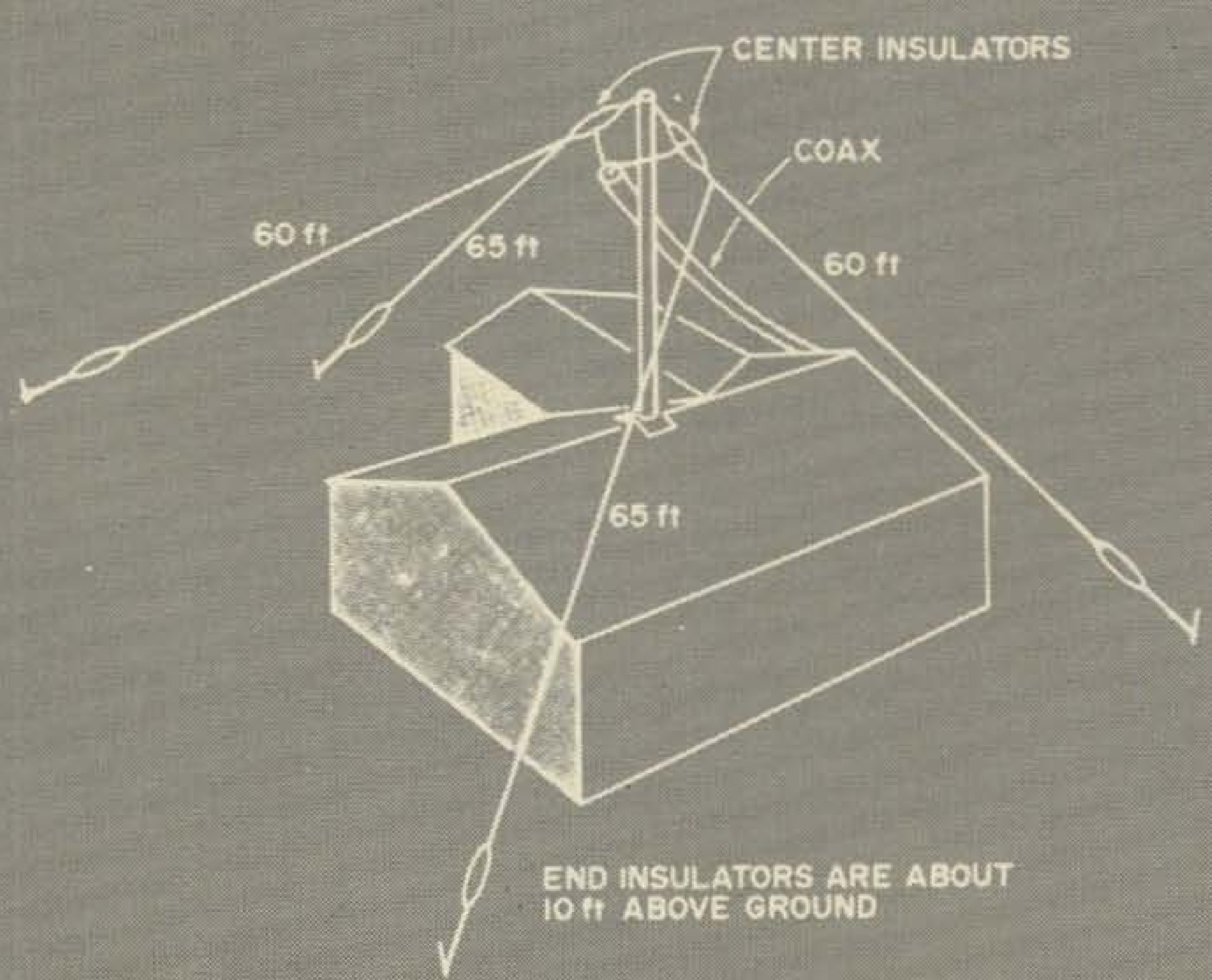


Fig. 3. Layout is shown actual-size alongside a composite view which gives component placement data.

William A. Brink WA6COB
415 Conestoga Way
San Jose CA 95123

The Four-Wire Inverted Vee



In a search for a better broadband antenna for 80 meters, I have devised one that works beautifully for me. Since it is possible that some of our readers might also be interested I will attempt to describe it to you.

I call this antenna the Four-Wire Inverted Vee, as that seems to best describe it. In the past I have used the conventional inverted vee on the lower bands with good results. This one seems to work better for me. Each side of the vee consists of two wires, one 60 ft long and one 65 ft long. This gives me one conductor near resonance at the top of the band and one near resonance at the bottom of the band. The center of my antenna is about 35 ft above the roof of my house (on top of a 40 meter vertical) which gives me an overall height of about 50 ft.

The best feature of this antenna is that it is coax fed with RG-11/U and tunes the whole band with a very low vswr. If it were fed with RG-8/U, the vswr might be even lower. Any rate, the highest vswr indication was 1.5:1 at 3.8 MHz. My measurements were all made with homebrew equipment that shows a good null on a Heath antenna. While the measurements are not precise due to the fact that 75Ω coax was used (rather than 50Ω), they are close enough to prove the effectiveness of the antenna system.

I have been using this antenna for the past six months and have achieved good results on both CW and RTTY. While I don't operate SSB since the funny license plan went into effect last year, I do want to point out that the antenna loads well in that portion of the band and should give the same results as at the bottom end. While I have not attempted to guess at the radiation pattern, I have worked a good many states on RTTY since I installed the Four-Wire Inverted Vee.

Frequency, MHz	Vswr with 50Ω bridge
3.5	1:1
3.6	1:1
3.7	1.35:1
3.8	1.5:1
3.3.9	1.22:1
4.0	1.22:1

William A. Brink WA6COB ■

PAGE SEVENTY-THREE
ACTION COUPON

When you've been done in by a company you get the best results if you take your gripe to the president of the company.

We've been done in by the FCC and the just-announced substantial increase in amateur license fees. We have a legitimate beef coming. . .one that we should take to the boss.

Use the 73 ACTION COUPON below to register your complaint with the Top Man. If you don't like to chop up your magazine, write the message on a separate paper or make a photocopy. Make a few for friends, too.

Send it to:

President Nixon
White House
Washington, D.C.

Dear President Nixon:

The first Russian Sputnik aroused considerable concern in the U. S. about our need for more engineers and technicians. Now, when we need technically trained people more than ever before, we see our teenagers turning away from the technical fields.

Amateur radio can fire the imaginations of our teenagers and lead them into technical careers. . .at least it can if the new higher tax on amateur radio licenses (just raised from $4 to $9) doesn't turn them away. This tax, quickly pushed through by the FCC to help balance their budget, increases the fees paid by radio and television stations (which seems reasonable since these are licenses to make money) as well as amateur operators, but does not increase the fee for commercial licenses (also licenses to make money).

Our country can ill afford this extra hurdle for teenagers wanting to come into amateur radio. This could have profound repercussions on the future economy and even the survival of our country.

Is this fee even fair? Some 40% of all amateur license exams are administered by the amateurs themselves, thus saving the FCC the expense. The whole works is on computer, so renewals are practically automatic. A dollar or two would be a fair fee for the actual service provided. Why should amateurs have to pay for the other services?

The Commission has refused to reconsider this matter. Please do what you can to intercede for us.

Signed ________________________ Call __________

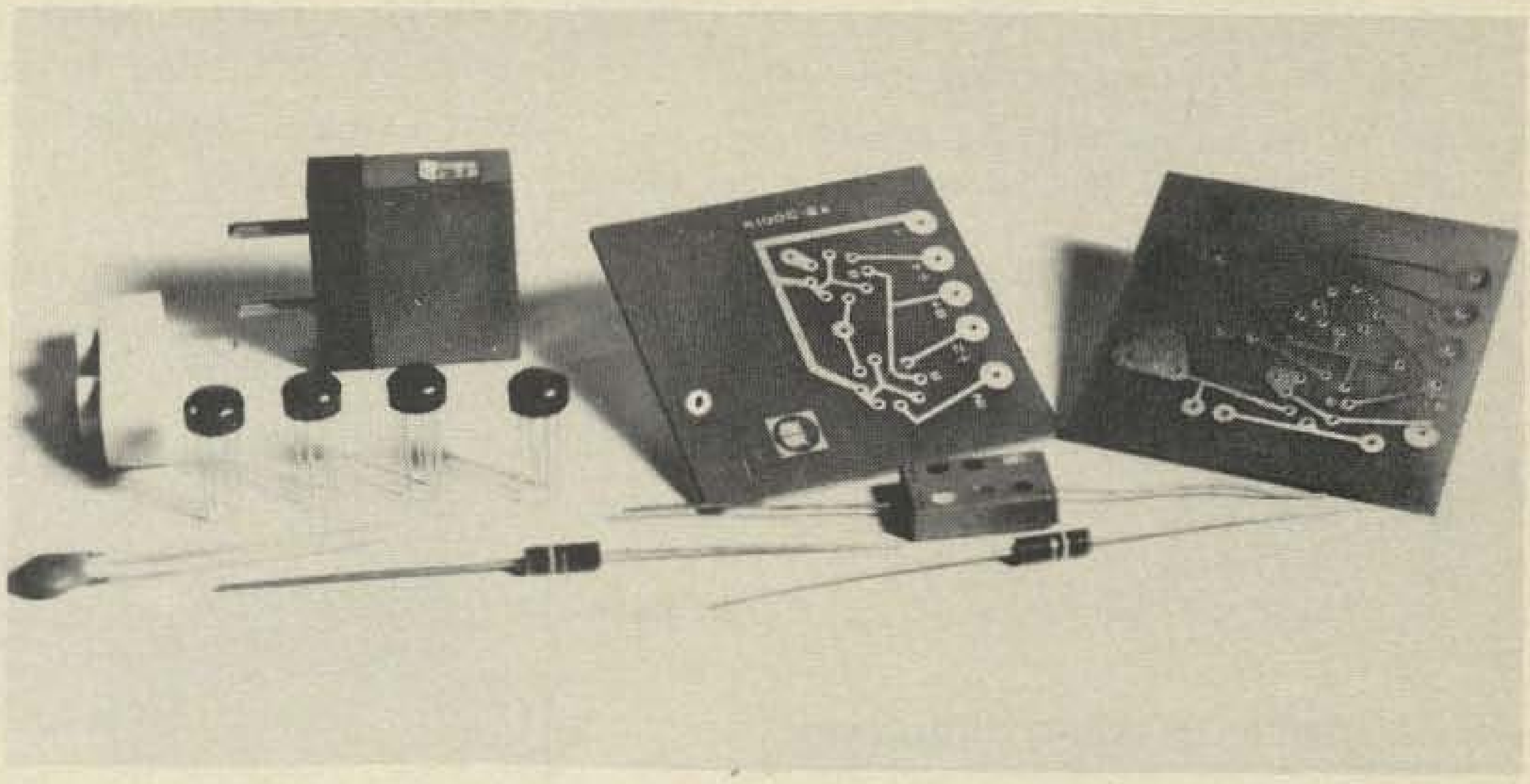
AN IC MARKER GENERATOR

D.A. Poole K4BBC
1223 Brookwood Drive
Winston-Salem NC 27106

Simple IC device gives marker signal when you approach the edge of your authorized band.

The incentive licensing regulations have created a need for identifying restricted band segments. The easiest method of doing this is by using a crystal-controlled oscillator to provide marker signals at the edges of the subbands (getting the Extra license is another good approach).

The marker generator described here provides calibration signals at 200, 100, 50, and 25 kHz intervals, usable up through the 6 meter band. Although the basic components shown were purchased in a kit (R&R Electronics, December, 1969. 73 Magazine) containing the two circuit boards, the generator could be



R&R (311 E. South St., Indianapolis IN 46225) supplies all components and PC boards in kit form.

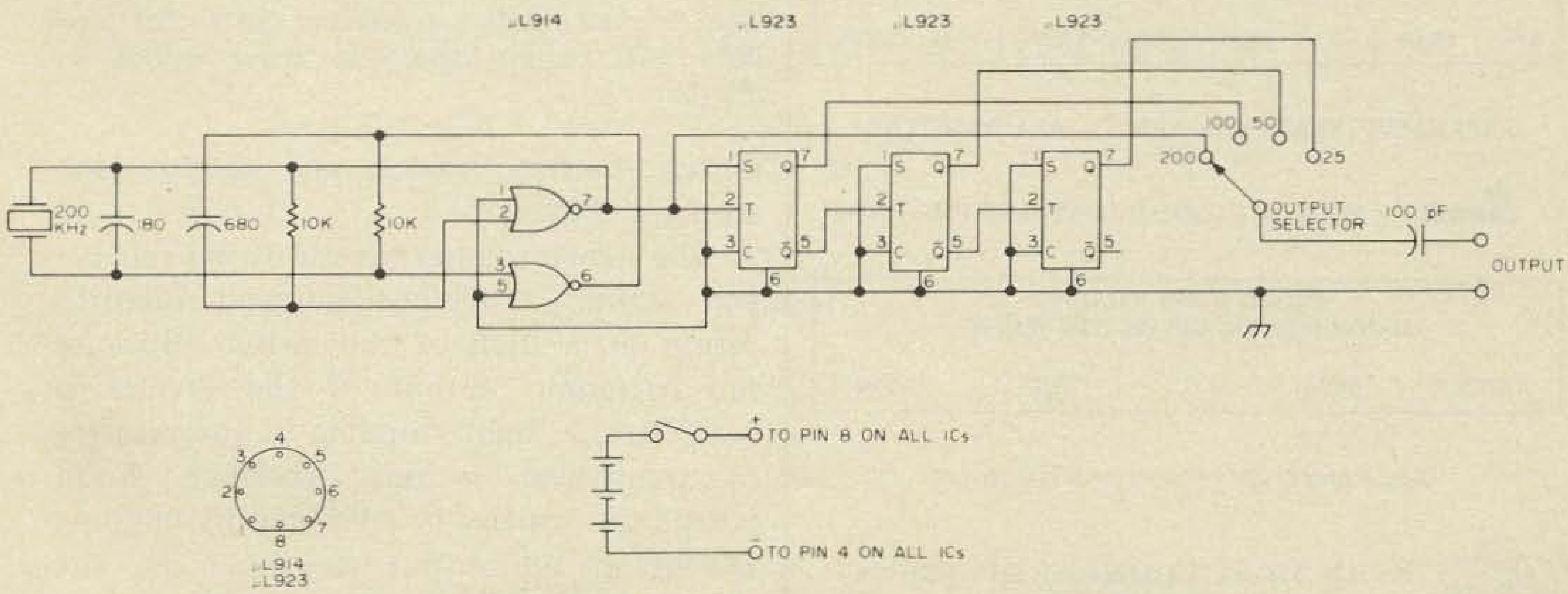


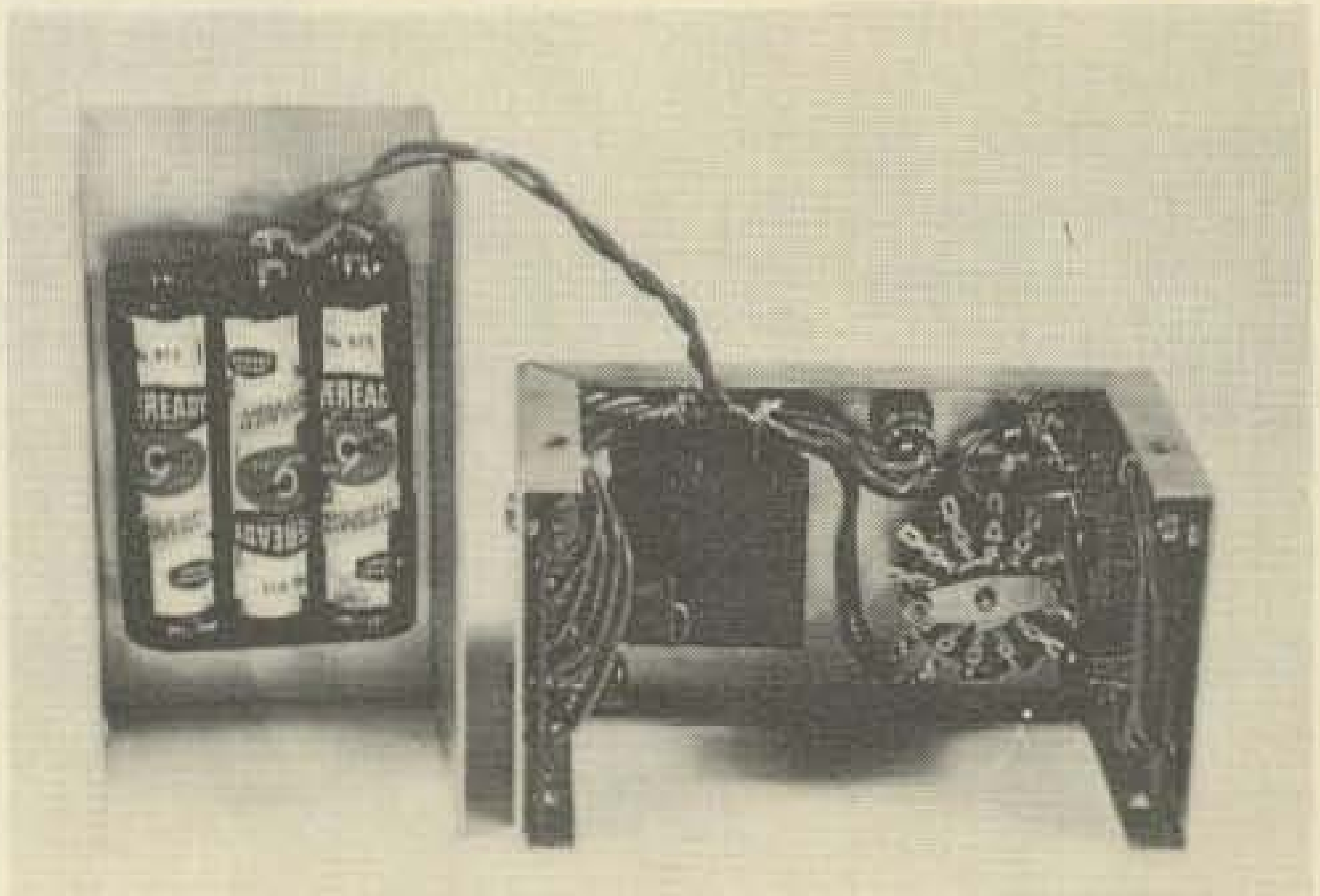
Fig. 1. IC interconnection and base diagram for the band-edge marker generator.

built on perforated board from individually purchased components.

The circuitry consists of a 200 kHz oscillator and three divide-by-two stages. In the oscillator, a Fairchild μL 914 integrated circuit is connected as a crystal-controlled multivibrator. A 200 kHz crystal is used because it is cheaper and more stable than the 100 kHz crystals usually used in marker generators. With the values shown the frequency is within a few cycles of zero-beat with WWV.

The output from the 200 kHz oscillator is successively fed to three μL 923 integrated circuits, each connected to divide the frequency by two. A rotary switch selects the desired output. Three penlight cells supply the 4.5V required by the integrated circuits.

The generator in the photo was built in a 4 x 2¼ x 2¼ in. aluminum box. The printed circuit boards with integrated circuits are attached to the box with screws and small spacers. The small rotary



The finished marker generator. Note that penlight cells mount handily in cover section of minibox.

switch, battery holder, and output jack are from Lafayette.

The generator has proved to be reliable and stable, providing subband identification at a flick of the switch. Because the harmonic output of the divider is quite strong, tight coupling to the receiver or transceiver is not necessary. Good results can usually be obtained by slipping the end of the output wire down into the shield of the first rf amplifier tube.

. . . K4BBC ■

IMPROVING REGULATION IN HIGH VOLTAGE SUPPLIES

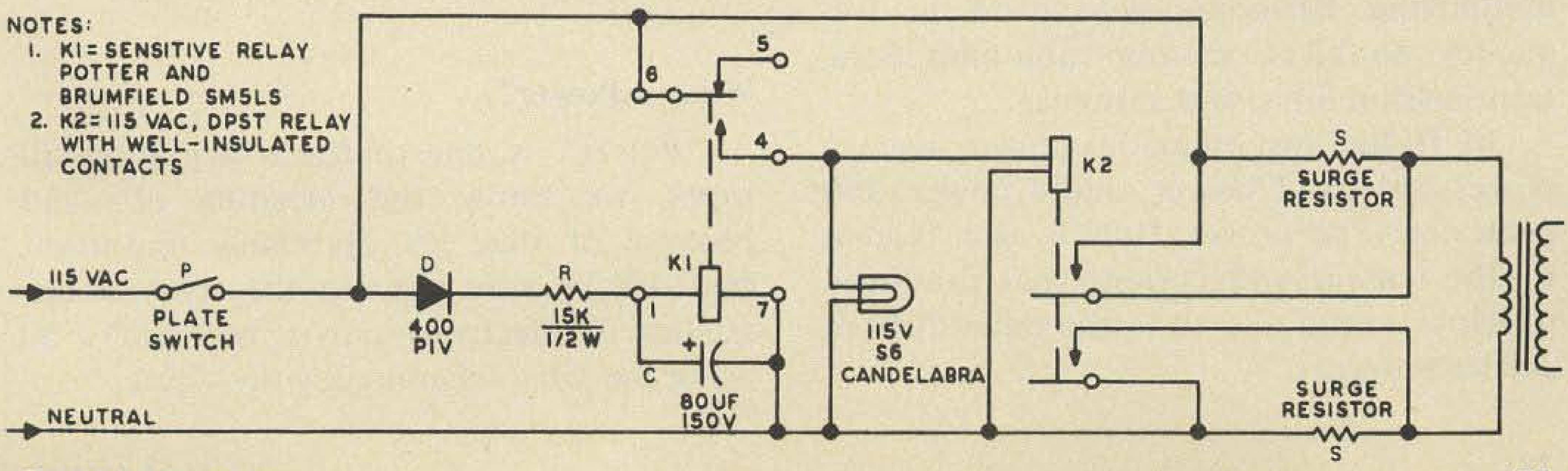
Some improvement in the regulation of a high voltage semiconductor power supply system with capacitor input can be obtained by shorting out the protective surge resistors placed in the secondary leads of the power transformer by means of a delay circuit. The amount of improvement, naturally, depends on the values of the resistors.

One method of accomplishing this objective is shown in the diagram.

When the plate switch in the primary of the high-voltage transformer is closed, the RC time constant provides a delay of about one second before the contacts of relay K2 close and short the surge resistors. Variation in delay from milliseconds to several seconds can be achieved by choosing values of R between 10 and 20 kΩ and/or substituting different values of C.

Since the time constant in the filter circuit of the power supply is so small, a delay of one second is sufficient to provide ample protection in shorting out the surge resistors when the power is turned on. A 115V isolating transformer must be used between the plate switch and the diode if the 115V line polarity is not observed.

Louis Berman K6BW ■



STUDY GUIDE GENERAL CLASS LICENSE

PART III

And more power to you.

It may seem that we're putting too much emphasis, in this study course for the General license examination, on the ultra-basic fundamentals of electricity and electronics. After all, nearly three-quarters of all the questions on the FCC's official "study list" deal with matters much more complex than those we have been examining since we began.

However, our stress on the ultrabasics is deliberate. With a strong understanding of the major principles of electrical physics as a foundation, the more specialized matters met on the actual examination will be much more solidly seen. In other words, we're going a bit slowly at the beginning, so that we can do a better job later on and make it all appear to be as simple as it really is.

Already covered has been the propagation of electromagnetic energy, through both wires and space, as well as the ideas of voltage and current, resistance and reactance, and Ohm's Law for both ac and dc. We're now ready to attack such puzzlers as power, decibels, and harmonic frequencies.

Specifically, this time we're going to look at the following three questions from the FCC study list (the numbers are those appearing on the official list):

15. What is a decibel?

16. What is a harmonic? List ways of minimizing harmonic generation in frequency doublers, vacuum-tube amplifiers, transmission lines, and antennas.

30. Define instantaneous power, average power, sideband power, audio power, and peak envelope power. How is each related to the voltage and current that produced it? How is each related to the unmodulated carrier power?

Most of the questions that appear on the official study list are extremely specific ones dealing with some narrow aspect of a general subject, and to provide you a broader base of knowledge we have followed the practice of rephrasing the questions into more general forms.

This time, we'll do that with two of them – but one is already about as general as it can get.

Our questions, therefore, will be a mixture of our own rephrasings, and the study list question which is already general. We'll start by asking "What is Power?", which will build us a bridge from what we already know about energy, voltage, and current, to the many ways in which power can be specified. We'll follow that up by learning "How is Power Measured?" to determine how the various kinds of measurement and specification of power relate to each other. Next, we'll find an answer to "What is a Decibel?" – and in the process we may be able to remove some of the traditional confusion which always seems to surround this subject.

We will then direct our attention to harmonics, asking first "What Are Harmonics?" and then "How Can Harmonics Be Controlled?" By the time we complete our look at these, you should know more than you really wanted to about the subject.

What is Power?

"Power" is one of those words we all *think* we know the meaning of – and because of this, it's extremely important that we be sure right at the start of our studies of electrical power that we're all using the *same* meaning for the word.

Dictionaries list many meanings for power. In everyday conversation, we speak of political power and powerful motors, of the power of public opinion, and the power of the individual. There's the power we get from the wall plug, and the power to keep going we get from our food. All of these are different kinds of power.

So let's ignore what we think we know about the meaning of the word, and develop a brand new definition to use during our examination of this subject. Let's begin by going back to what we learned in the first chapter of this course, about current and voltage.

There, you may remember, we found out what "current" and "voltage" were by relating them to the two kinds of energy involved in the magnetic field and the electric field. We found that either of these two kinds of energy ("actual energy" and "potential energy") could apparently exist indefinitely by itself so long as nothing moved, but that as soon as "motion" came into the situation the total energy present began changing from one form to the other, and that this change of form of the energy was what we know as "electric" and "magnetic" effects.

While we didn't bring it out in so many words at that time, "motion" itself involved the use of energy – which might mean that putting motion into our balanced situation simply unbalances it by adding additional energy. This is one of the areas in which physicists are still uncertain as to exactly what goes on, but the assumption appears reasonable in view of the current belief that everything in existence is either energy, or equivalent to energy, and that the total amount of energy in the universe cannot increase or decrease but must remain forever unchanging.

What all of this means to us at this point in our studies is simply that any use of electricity involves a use of energy.

We also found, earlier, that resistance in a circuit causes some of the electrical energy present to be dissipated in the form of heat – which, again, is another kind of energy. If it won't cause too much confusion, we can consider that electrical energy which is changed to heat energy has been "used up"; we do not mean by this that it's no longer energy, but merely that it's no longer in the right form to be used electrically. In contrast, electrical energy which has been "locked up" by a change of phase relationships in an ac signal is not used up, because we can easily get to it again by changing the phase relationships back again.

When we do anything at all to electrical energy by means of our circuits, we must "use up" at least a part of that energy. Some of the energy we "use up" is wasted – that is, it doesn't do anything effective for us. If the circuit is operating properly, though, most of the energy "used up" will be used in doing what we want the circuit to do.

For example, the whole purpose of a radio transmitter is to transmit information to one or more other locations by radiating radio energy from the antenna. The energy which we radiate is "used up" so far as the transmitter is concerned; we don't get it back to use again, but must continue to supply more energy in the form of the operating voltages which keep the rig going.

Whenever we use up energy in this manner, it's convenient to be able to determine how much we are using at any specific time, as well as to know how much we have used since we began to use it.

Now we get back to our immediate subject, power. "Power," as it applies to electricity, is simply the rate at which electrical energy is used. This is *not* the same as the amount of energy used, any more than "miles per hour" is the same as "distance." The power measures only the *rate* of energy use.

Back in the first chapter, we learned that voltage is a measure of electrical pressure or potential, while "charge" is a measure of the actual amount of energy at any instant. "Current" is a measure of the *rate* of "charge," and so "power," which is the rate of energy usage, must be related to both "voltage" and "current."

And the formula for determining power is simple: power equals voltage times current. If potential is in volts and current is in amperes, the resulting power will be in the unit of power, "watts" (for James Watt, inventor of the steam engine).

In physics, of which electronics is a branch, "power" is the same kind of thing as "work," and conversion factors exist which enable us to convert units of power into units of work. For instance, 746 watts equals 1 horsepower.

Notice that because power is a measurement of rate, like "miles per hour," rather than an absolute measurement such as "distance," it tells us nothing about the *total* amount of energy used. Just as the question "Which goes farther, a bicycle moving at 10 mph or an airplane doing 500 mph?" cannot be answered until the time of travel of each is known (if the bicycle goes for 72 hours while the airplane goes for only half an hour, the bicycle will go nearly three times as far), neither can the question "Which uses more energy, a 5W transmitter or a 50 kW transmitter?" be answered until the time during which each is operated is known. The 5W transmitter must operate 10,000 times as long as the 50 kW one to use the same amount of energy – but if it operates more than 10,000 times as long, it will use more!

To measure total energy consumption, we use such units as the kilowatt-hour or the watt-second. One kilowatt-hour is the amount of energy used by a 1 kW device in one hour, or a 1W device in 1000 hours, or any other combination which multiplies out the same way when power in kilowatts (thousands of watts) is multiplied by time in hours. Similarly, a watt-second is the amount of energy used by a 1W load in one second, or simply power in watts multiplied by time in seconds. The watt-second is also known as the "joule," after the physicist who first stated many of the fundamental ideas about energy and power, and is the standard unit of electrical energy usage. In practice, power companies charge for their product by the kilowatt-hour while photographers rate their strobe-light energy storage capabilities in watt-seconds or joules, and radio operators seldom worry about either since they are more concerned with the rate of energy use than with the total amount used.

How is Power Measured?

We've just met one way in which power is measured – in "watts." And we have learned that 1W is the rate at which energy is used in a circuit which operates at a potential of 1V and requires an energy flow of 1A. We also met the "kilowatt," which is 1000W. Now let's look at some of the other measurements of power.

Suppose for a start that we wanted to know how much power was required by a circuit operating at 100V dc, but that for some reason we had no ammeter with which to measure its current. We do know, however, that its resistance is 250Ω.

We can apply Ohm's Law using the known values of voltage and resistance to determine how much current flows. This tells us that current equals voltage divided by resistance, so we know that the current is 100/250 or 0.4A.

We can then plug this 0.4A figure into the power equation $P = EI$ to get power as 100V times 0.4A, or 40W.

For a shortcut, we can combine the equation of Ohm's Law that tells us $I = E/R$ with the power equation $P = EI$ by substituting the entire right-hand half of the Ohm's Law equation into the power formula in place of the I. This gives us a new power formula, $P = EE/R$. Since E times E is usually written as "E squared" (E^2), this gives us $P = E^2/R$, which defines power in watts as the square of the applied voltage, divided by the circuit resistance.

The same thing can be done if we know current and resistance but do not know voltage. In this case, we use Ohm's Law to determine voltage ($E = IR$) and substitute the "IR" from that equation in place of the "E" in the power formula to get $P = IIR$, or $P = I^2R$. That is, power dissipation in a circuit is equal to the square of the current, multiplied by the resistance.

The relation between power dissipation, current flow, and resistance which we have just developed is extremely important throughout electricity and electronics. It's the reason, for instance, that the power distribution circuits which carry ac power around the country from generating plants to the ultimate users operate at such high voltages. By using high voltage, current can be kept comparatively low while transmitting the same amount of power. Keeping current low reduces the I^2R loss in the power lines, so more of the energy gets to the ultimate user and less goes to provide a foot-warmer for stray birds.

It's also the reason why a high-Q tank circuit in a ham transmitter may get hot enough to melt its plastic coil supports, even when there's apparently very little power going anywhere. A tank circuit with high Q has high circulating current, which may be measured in the hundreds of amperes, and the wire of the coil has a definite minimum resistance. If circulating current is 100 amperes and coil wire resistance is only 0.01 ohm, the I^2R power dissipated in the wire is still 100 x 100 x 0.01 or 100W. And a hundred watts worth of heat is quite a bit; if you don't think so, touch a 100W light bulb after it's been on for an hour, or maybe the tip of a 100W soldering iron.

The three major ways of determining power in watts, then, are by multiplying voltage and current ($P = EI$), by relating voltage and resistance ($P = E^2/R$), and by relating current and resistance ($P = I^2R$). These equations, like Ohm's Law, work for all dc circuits, and for resistive ac circuits with certain restrictions.

The major restriction upon use of these equations with ac circuits involves the *units* of measurement to be used. With dc, a watt equals the power of a volt at a current of one ampere. When ac is introduced, the "voltage" and current are always changing – and this means that the "watt" becomes open to confusion unless we restrict things.

Even if we follow the conventional engineering standard and ignore all ac except the kind which has a sine waveform, both the current and the voltage are continually varying from a negative peak value through zero to a positive peak value and back again. To get a "power" calculation, we must choose which of these unlimited voltage and current levels to use.

While we might at first be tempted to use the "peak" levels, if we did we would find that "volts times amperes" would give us a figure that represented more power than "volts times amperes" in a dc circuit does. In fact, the figure would be just twice as great as in a dc circuit.

This, of course, is not a happy state of affairs. A watt should be a watt, regardless of whether it's dissipated in ac or dc circuits.

If, instead of the "peak" levels, we use levels which will produce a "watts" figure just half as large, everything will come out as it should. But we cannot do this by using half the peak voltage and half the peak current, for that would give us half of a half, or one fourth, the power.

What we have to do is find a voltage level and a current level which multiply out properly. If we divide the peak value in each case by the square root of two, we will have such levels.

What's more, these levels turn out to be the "rms" or "effective" levels we have already met. In fact, the "rms" levels were chosen as the "normal" values for ac voltage and current specifically because they do provide power figures which are equal to those obtained with dc. Whenever ac power is mentioned, unless it's qualified with some sort of modifying word, what is meant is the power determined by multiplying rms voltage by rms current.

Another restriction on the determination of power in ac circuits comes from the fact that power can only be dissipated when voltage and current are in phase. That is, nothing but *resistance* can dissipate power. Ac circuits, however, normally contain reactance as well.

Reactance acts just as does resistance to limit voltage or current in the circuit – but this control is not achieved by dissipating the power into heat energy. Instead, the phase is altered. Since no power is dissipated by doing this, the effect cannot be expressed in "watts" or any other unit of power.

To cover such situations, the unit known as the "voltampere" was invented. Like power, it's obtained by multiplying rms volts times rms amperes, but it doesn't necessarily indicate any use of energy. If the circuit is composed of resistance only, its "voltampere" figure will be the same as its "power" figure; if reactance is present, there will be more "voltamperes" than "watts," and the difference between them indicates the amount of reactance. The ratio of "voltamperes" to "power" is known as the "power factor," and you may see it in the ratings for transformers or electric motors.

Now that we've seen how ac power is calculated and why the rms values of voltage and current are used, let's look at some of the modifiers often attached to the phrase – for instance, "average power."

This is a term most frequently used with respect to the power of an amplitude-modulated radio signal, and has nothing to do with "average voltage" or "average current." Instead, it's the average of the signal's rms power level, taken over several cycles of the modulating signal.

For this to make any sense, we must jump a little ahead of ourselves at this point and take a quick look at amplitude modulation (more exact discussions of modulation will come quite a bit later in this course). Figure 1 shows the

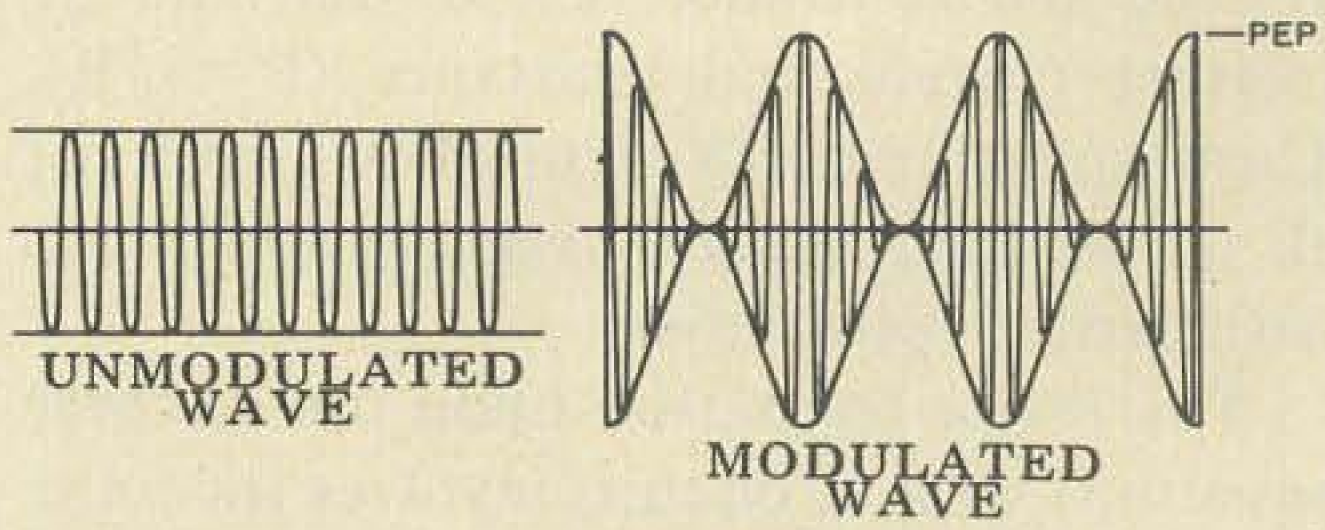


Fig. 1 Waveforms of unmodulated or "carrier" signal, and complete modulation envelope for 100% amplitude modulation are necessary to illustrate some of the various power measurements often encountered.Peak envelope power, for instance, is the power calculated from voltage and current at modulation peak, as indicated at right.

"envelope" waveforms of both a modulated and an unmodulated AM signal. You can see that the modulated waveform rises to higher peaks than does the unmodulated or "carrier" signal.

If the modulating signal is a sine wave, and if the maximum amount of modulation is applied as it is in Fig. 1, the total power of the modulated signal (averaged over several cycles of modulation) will be half again larger than that of the carrier. The "average power", then is 1.5 times greater with such modulation than without.

"Instantaneous power," on the other hand, refers to the power figure that results from taking one specific instant during a cycle and multiplying the voltage at that instant by the current at the same instant. These are *not* rms values – the "instantaneous" values are used instead. If we choose the instant when both voltage and current are peak, the "instantaneous power" comes out to twice the "average power" – and in the modulated signal with its higher peaks, the maximum "instantaneous power" is four times as great as the carrier's "average power."

The maximum "instantaneous power" level possible for a modulated signal – that is, the instantaneous power at the peak of the modulation cycle – is called the "peak envelope power" or "PEP." This figure is often used to rate output power of SSB transmitters, and to compare the power levels of various types of modulation.

We have just noted that the average power of a fully modulated signal (if the modulation is itself a sine wave) is 1.5 times that of the carrier alone. The "extra" power is contained in the sidebands which are produced by modulation, and so is known as "sideband power." From this, we can say that "average power" of a modulated signal of any kind is equal to the "carrier power" plus the "sideband power."

"Audio power" is that power at audio frequency which furnishes, either directly or indirectly, the sideband power. If plate modulation is used, audio power and sideband power will be approximately the same number of watts (the only difference is that caused by the fact that the modulation process cannot be 100% efficient). The difference between the two in this case is that "audio power" exists as an af signal, while "sideband power" is at radio frequency.

All of these various kinds of power are related directly to the voltage and current which produce them, and all except instantaneous power and PEP are the product of rms voltage times rms current. Their relation to the "carrier" power level varies with the waveform of the modulating signal and the particular kind of modulation technique employed, and we'll go into that more deeply when we get to modulation.

When we attempt to measure the power involved in an ac signal which is *not* a sine wave, we have a problem. While it's theoretically possible (as we shall soon see) to analyze *any* ac waveform into a combination of sine waves, this is not a practical approach to power measurements.

The most accurate way to measure the power content of a non-sine-wave ac signal is to dissipate the power into heat by means of a suitable resistor, and use a thermometer to measure how much heat it produces. From this, we can determine the power figure by converting degrees-of-heat-rise to calories, and calories to watts.

Such an instrument is known as a "bolometer," and is often used in microwave work to measure the power of pulsed signals.

If the departure from a sine waveform is not extreme, many persons simply calculate peak instantaneous power from the voltages and currents as displayed on a scope, and divide that by two to get approximate rms power. Accuracy of this method depends on just how close to a sine wave the signal happens to be. For voice signals, it's not too accurate – but the error is such as to make you believe you have more power than is really present, so it turns out to be simply a safety factor in practice.

What is a Decibel?

Contrary to what you may believe or have heard, the decibel (abbreviated "dB" and often pronounced "dee bee") was *not* invented solely for the purpose of making an already complex situation more confusing. In fact, the whole idea behind the decibel was to make things simpler!

And once decibels are adequately understood, they do simplify matters. The problem is like that of making friends with a porcupine; no matter which direction you approach from, it's only too easy to get stabbed unexpectedly by something painful.

Most textbooks approach decibels from a mathematical viewpoint, which isn't such a bad idea, except that you don't really have to comprehend the math behind them in order to make good use of them. We'll try another approach.

In many situations involving a comparison between two values of the same quantity – such as the amount of light present in a room, or the intensity of sound produced by a PA system – it's not so much the *absolute* difference between the values that's important, as the *ratio* between them.

That is, you wouldn't compare the brightness of two different light bulbs by saying that one was "25 watts more powerful" than the other. Instead, you would say that it was "twice as bright."

If one bulb was a 25-watter and the other rated at 50 watts, you might expect twice the brightness from the doubling of power, but you wouldn't expect to keep getting twice the brightness every time you went up another 25W in power.

Actually, the relation between brightness and wattage of the bulb isn't really all that simple and we don't mean to imply that it is. Our purpose is to bring out the difference between the *ratio* of "twice" or "double," and the *absolute* increase of 25W.

Musical tones offer another example. On most pianos, the note known as "middle C" has a frequency of approximately 512 Hz. The next higher C is about 1024 Hz, and the C above that is about 2048 Hz. The absolute values determine whether the tone is at the top or bottom of the keyboard's range, but the 2-to-1 ratio is what makes it a C rather than a B or a D.

Now we bring decibels back into the picture. All that the decibel amounts to is a unit for the measurement of power *ratio* rather than any absolute value. Any time power is doubled, it has been increased by 3 dB, no matter what the starting point. If the power is cut in half, it has been decreased by 3 dB.

While the decibel is the unit normally used in all technical work, it is not the "basic" unit. The basic unit of power ratio is the "bel," named for Alexander Graham Bell of AT&T renown, and it's defined as being a power ratio of 10:1. The "decibel" is one-tenth of a "bel" – but it's not a 1:1 ratio (the 1:1 ratio is zero bels or 0 dB). And right here is one of those porcupine quills.

The problem is that *ratio* itself involves multiplication or division. A 2:1 ratio implies multiplication or division by 2, a 10:1 ratio by 10, and so forth. The *units* of ratio, though, are not multiplied or divided, but instead are added or subtracted. a 10:1 ratio is 10 dB. A 100:1 ratio is not 10 *times* 10 dB or 100 dB, but rather is 10 *plus* 10 dB or 20 dB.

If you're familiar with the mathematics of a log table or of exponents, you have probably realized by this point that the decibel behaves like the log of the true ratio. The bel, in fact, *is* the log of the power ratio, and since 10 dB equals 1 bel, the formula for calculating decibels becomes merely "10 times the log of the power ratio." If you have a log table handy, the ratio itself can be calculated by logs – but that's not required in order to make use of decibels, as we shall see shortly.

Strictly speaking, the bel and decibel are units for the measurement of *power* ratios and cannot be used for measuring anything else. This might appear to be rather confining until you recall that power is simply a measurement of the rate at which energy is used, so that whenever energy is actually being dissipated you have power whether you realize it or not.

The situation isn't helped any, though, by the fact that many people speak (incorrectly, as it happens) of "voltage decibels" and "current decibels."

These "voltage" and "current" decibels came into vogue because it's possible to calculate power when only voltage or current, and circuit resistance, are known. We saw this in the previous section of this installment, and developed a pair of "shortcut" equations by combining the power formula with the appropriate form of Ohm's Law.

Since decibels are calculated by first getting the ratio between two power figures, then taking the log of that ratio

and multiplying by 10, it's possible to plug the "shortcut" power equations in place of the actual power figures, and come up with a corresponding pair of decibel equations which apparently compare voltages or currents. Both the shortcut power equations involve squaring the voltage or current figure, and when we move this into the decibel equation we do the squaring by multiplying by 20 rather than 10.

But what we have is still a *power* ratio, and in addition we have introduced a restriction that both voltage figures (or current) must be in circuits of identical resistance.

Since a 2:1 power ratio comes out to 3 dB and a 2:1 voltage ratio comes out as a 6 dB, people began calling the decibel values obtained from the composite equations "voltage" or "current" decibels and the belief grew that they were somehow different from "power" dB.

Actually, there's no difference between one set of dB and any other. The apparent difference is actually the difference between a power ratio and a voltage ratio.

If we double the voltage present across a resistor without changing the resistance value, the current through it must also double (Ohm's Law proves this). That means that when we figure the power, we must multiply twice the voltage times twice the current, and we come out with a power ratio of 4:1.

A power ratio of 4:1 comes out to be 6 dB, and a voltage ratio of 2:1 is also 6 dB. Since a 2:1 voltage ratio across the same resistance (which you recall is a requirement for using the "voltage decibel" equation) is the same as a 4:1 power ratio, you can see that there's no difference in the decibels themselves whether we get them by voltage/current calculations, or by power calculations.

If you're going to use log tables to deal with decibels, here are the two equations:

$$\text{decibels} = 10(\log \text{power}_1 - \log \text{power}_2)$$

$$\text{decibels} = 20(\log \text{voltage}_1 - \log \text{voltage}_2)$$

For current, use the "voltage" equation but substitute current in place of voltage. For either equation, the larger of the two quantities is always used as the first, so that the result will always be positive.

But you don't need to use a log table or a slide rule – or even know what they're all about – to figure out decibels accurately enough for all practical purposes. All you need to do is memorize a couple of facts and four specific decibel values.

We've already met the facts – they are that decibels add together, so that if you know a 10:1 ratio is 10 dB, you can figure out a 100:1 ratio as being 20 dB and 30 dB as being 1000:1. The process can continue as long as need be. Adding dB multiplies the ratio, and subtracting dB devides the ratio. If 100:1 is 20 dB and 2:1 is 3 dB, then 50:1 is 20–3 or 17 dB.

Now for the values. One decibel is 1.25:1, or 5:4. Three dB is 2:1; 5 dB is 3.16:1, and 10 dB is 10:1. From these, we can get any other values we may need by adding and subtracting. For instance, 9 dB is 3+3+3 dB, or 2x2x2 or 8:1.

From just these values, you can find out how many decibels any specific ratio amounts to, or conversely what ratio is meant if you have a known number of decibels, because you can build up any number you want by proper addition or subtraction of 1, 3, 5, and 10.

For instance, how many decibels stronger than a 25W transmitter is a 500W one? First, we convert the absolute power figures of 500W and 25W to a ratio by dividing 500 by 25, and discover that the ratio is 20:1. Next, we divide the 20 by 10 and note down the 10 dB effect of that division; the resulting ratio is 2:1. But a 2:1 ratio is 3 dB, so we add 3 dB to the 10 we already have, and the answer is 13 dB.

Let's try another one. Good operating practice requires that all spurious products from a single sideband transmitter be at least 35 dB below the power level of the transmitted sideband output. If we have an SSB rig with a PEP of 150W, how much power can we let out as "garbage" without violating these standards?

This time, let's take care of the odd 5 dB first. To do so, we divide our 150W PEP figure by the 5 dB ratio equivalent, 3.16, and come up with about 47.4W. This would be 5 dB below the PEP, but we want to be 35 dB below, so we still have 30 dB to go. But 30 dB is a 1000:1 ratio, so dividing 47.4W by 1000 gives us the answer – 0.0474W, or a little less than 50 mW PEP of garbage would be permissible.

With this technique, you don't need a log table or a slide rule to be a decibel expert – and comparison of power levels is as simple as adding and subtracting.

One point deserves special mention here; the S-meters on many receivers are calibrated in both "S-units" and "decibels over S9," and most operators believe an "S-unit" equals 6 dB.

Actually, however, the "dB" indicated on S-meters bear little if any resemblance to true decibels. We'll prove it:

Most S-meters will indicate a signal that is supposed to be "60 dB over S9." That means a signal having one million times the power of one which produces an S9 reading, which would require one thousand times the voltage of an S9 signal at the receiver input terminals.

Most S-meters, also, are calibrated to read "S9" at an input signal level of 25, 50, or 100 mV.

That means the "60 over 9" signal, if it really *were* 60 dB over S9, would be at least 25V at the receiver input. If the antenna is connected to the receiver via 52Ω coax, that 25V level would amount to about 12W of rf power coming into the receiver. Many transmitters which won't put out 12W to their own antennas, however, will produce solid "60 over 9" signals on receivers several miles distant! If the S-meters were anything like accurate, this would mean that the signal had to *gain* power between the transmitter and the antenna – but in fact it loses power rather rapidly.

Had enough of decibels for now? Let's move on to another subject which also deals with ratio – but ratio of "frequency" rather than of "power" or "energy."

What Are Harmonics?

Back in the first chapter of this course we made the acquaintance of ac, and met one of the major characteristics of any ac signal – its frequency.

An ac signal may have any frequency greater than zero, although most common ac signals lie in the range from around 10 or 15 Hz up to several thousand MHz. Physicists consider light itself as an ac signal of exceptionally high frequency (so high, in fact, that it's not normally measured in hertz at all), and for some purposes it turns out to be convenient to treat dc as being an ac signal with a frequency of zero.

Since an ac signal may have any frequency at all within this unimaginably wide range, it's only natural that some signals must have frequencies which are exact multiples of those of other signals. For instance, a 24 Hz signal is at two times the frequency of a 12 Hz one, or 3 times that of an 8 Hz signal, or 4 times a 6 Hz signal, and so forth.

We can go the other way, too. For instance, if we start with an 8 Hz signal, we could have signals at 2 times 8 or 16 Hz, 3 times 8 or 24, and so forth all the way up until we run out of numbers.

The point is that no matter what the frequency of the signal with which we start, other signals may exist at frequencies which are exact multiples of our original. As it happens, these other signals bear some special relationships to our original signal, and for this reason are known as the "harmonics" of the original (which is itself known as the "fundamental frequency" signal or merely "the fundamental").

One of the special relationships between a fundamental and its harmonics involves their mutual timing. If we start all the signals from zero at the same instant, then whenever the fundamental's voltage (or current) waveform crosses zero, so will that of each harmonic.

This is always true, because of the definition of a harmonic as "an exact multiple" of the fundamental frequency. If the frequency is two times that of the fundamental, then during the time that the fundamental goes through one half of its cycle and gets back to zero, the harmonic will complete a full cycle and reach zero at the same instant. When the fundamental has completed one full cycle, the harmonic has completed two, and again they reach zero together. The harmonic also goes through zero when the fundamental is at either peak – but we don't care about that right now.

If the harmonic frequency is three times that of the fundamental rather than twice, then when the fundamental is half-way through its cycle and reaches zero, the harmonic will have completed one full cycle and will be half-way through another one. At the end of a full cycle of the fundamental, the harmonic will have completed three cycles.

Harmonics are identified as second, third, and so forth, according to the multiplying factor involved. The second harmonic is at a frequency two times that of the fundamental, the third at three times fundamental frequency, and so on. The "order" of a harmonic usually refers to its separation from the fundamental; second, third, and fourth harmonics are often called "low-order," while fifth and higher are known as "high-order." The dividing line between "low" and "high" harmonics, though, depends largely on the particular problem under discussion.

The same arguments which we just applied to the second and third harmonics apply to all of higher order as well. Those which are at even multiples (even harmonics) of the fundamental will be completing a cycle when the fundamental reaches the midpoint of its cycle, and odd harmonics (those at odd-numbered multiples) will be in the middle of a cycle when the fundamental is at midpoint.

Because the timing relationship between a signal and its harmonics is made constant in this manner by the definition of harmonic, we can talk about "relative phase" between a signal and its harmonics although in general, "phase" and refer only to timing differences between two signals of identical frequency.

That is, an odd harmonic which is "in phase" with its fundamental crosses zero at the same time as the fundamental, and is going in the same direction (whether positive or negative).

The same signal "180 degrees out of phase" with its fundamental will still cross zero at the same instant as the fundamental every time, but will be always going toward opposite polarity.

If the two are "90 degrees out of phase" with each other, the harmonic will be at a peak value whenever the fundamental crosses zero. (See Fig. 2 for an illustration of these phase relationships between a signal and its third harmonic.)

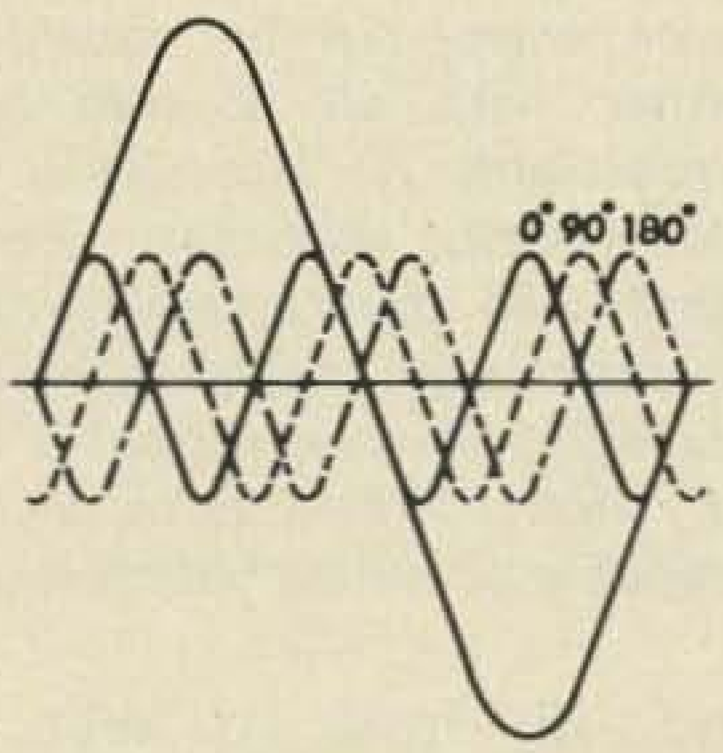


Fig. 2. Phase relationships between fundamental and odd harmonics are illustrated here using third harmonic. At 0 degrees, or in-phase condition, harmonic and fundamental both cross zero line at same time going in same direction. At 180 degrees, or opposite-phase condition, they cross in opposite directions. The 90-degree phase relationship is midway between these (dotted line).

The exact description of phase relationships between a signal and its harmonics depends to a large degree upon the order of the harmonic. Whether an even harmonic is "in phase" or "180 degrees out of phase" depends upon which half-cycle of fundamental you start from, as shown in Fig. 3 for the second harmonic.

Another special relationship between a signal and its harmonics involves the way in which they combine to produce signals which are not sine waves at all. Take, for example, a combination of fundamental and third harmonic such as that shown in Fig. 4.

When both these signals are present in a circuit which permits them to combine, the net energy at each instant is the total of the energy in both signals. At certain moments they add together, and at others they cancel; the result is the waveform shown by the heavy line in Fig. 4.

If we change the phase relationship between the two signals, the waveform changes, because the addition or cancellation occurs at different times.

Similarly, if we introduce still more harmonics into the mixture, we can produce far different waveforms.

When enough different harmonics are present, and with the phase of each being independent of all the rest, we can reproduce any ac signal at all. This is another reason why engineers deal only in sine waves although sine waveforms are rare in nature; any other signal may be treated as merely a combination of sine waves, each of appropriate phase and strength.

Even such decidedly non-sine waveforms as the square wave (Fig. 5C) can be built up from sine waves. Figure 4 showed the result of combining a fundamental and its third harmonic. Figure 5A shows what happens to this when the proper proportion of fifth harmonic is added, and Fig. 5B shows what happens when the first 100 odd harmonics are included; it's difficult to distinguish between the waveforms of Fig. 5B and Fig. 5C.

So now we have met the family of harmonics, and have seen that they are essential to most types of actual ac signals. Yet most discussion of harmonics centers upon methods of suppressing them, or preventing them in the first place. Why?

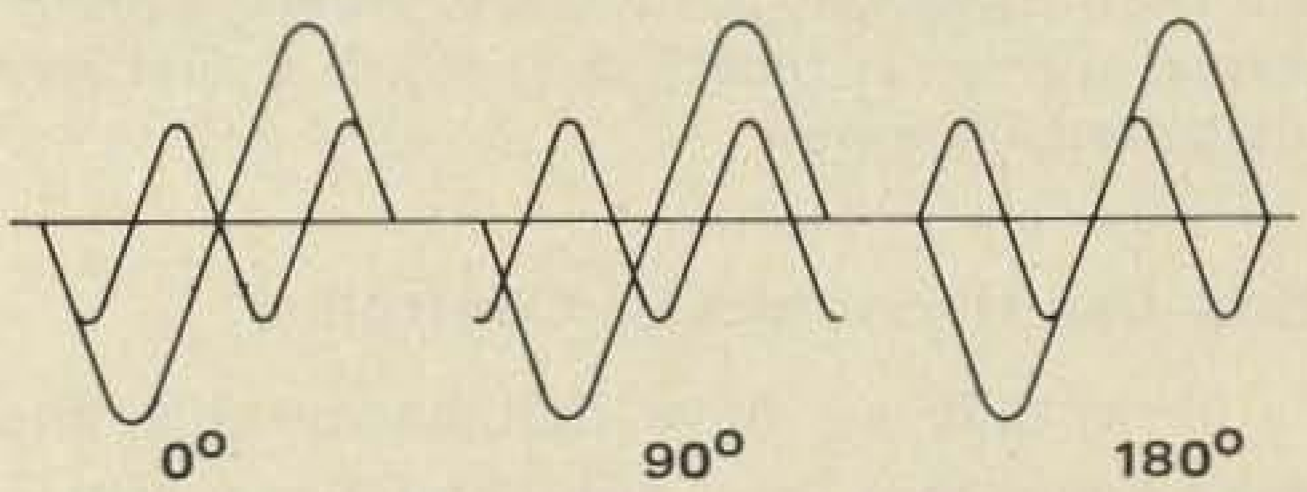


Fig. 3. Phase relation between fundamental and even harmonics (second is shown here) is a bit more confusing, since both the 0- (in-phase) and 180-degree relationships appear very similar.

A harmonic is good only if you want it. Like anything else, an unwanted harmonic or one which you cannot control is to be avoided whenever possible. FCC regulations prohibit transmission of excessive amounts of harmonic energy, and almost anything you can detect is considered to be "excessive." Yet we do make extensive use of harmonics in ham transmitters – always attempting to keep them under control.

Harmonics may be generated either deliberately or by accident, whenever a sine-wave signal is distorted by any means. If the signal was sine to begin with, and is not now, something must have been either added or taken away to make it different.

As it turns out, what was added was harmonic energy.

The distortion need not occur in an amplifier. *Any* action which distorts the signal will suffice. Most harmonic generation in ham transmitters, though, occurs in the amplifiers, because the "normal" rf power amplifier circuit distorts the signal greatly in the interests of handling high power with comparatively small tubes.

This distortion generates myriads of harmonics, because the waveform is very close to a square wave. All of them must be controlled. How to do so? That's our next subject.

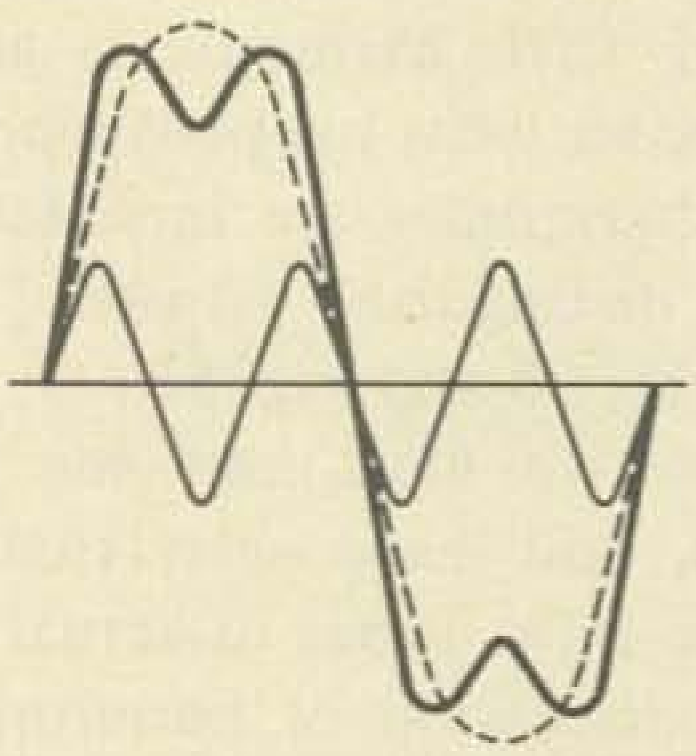


Fig. 4. Sine waves can be combined to produce any ac waveform. Combination of fundamental and third harmonic, shown here, produces tooth-shaped waveform (heavy line) which is first step toward square wave.

How Can Harmonics Be Controlled?

Now that we have met harmonics, and have seen that the only bad harmonic is one which we do not control, we're ready to try to find ways to control them effectively.

In general, harmonics can be controlled by either or both of two major routes. The first concentrates upon preventing their existence, while the second places the emphasis upon containing them so that they cannot escape.

Most practical situations require both types of control. The first, alone, is impractical and probably impossible as well, because all the efficient rf amplifier circuits capable of handling high power also generate harmonics prolifically. Without the first, the second becomes an unimaginably large job.

Both together, though, hold down the strength of the harmonics which are generated, and make them easier to bottle up.

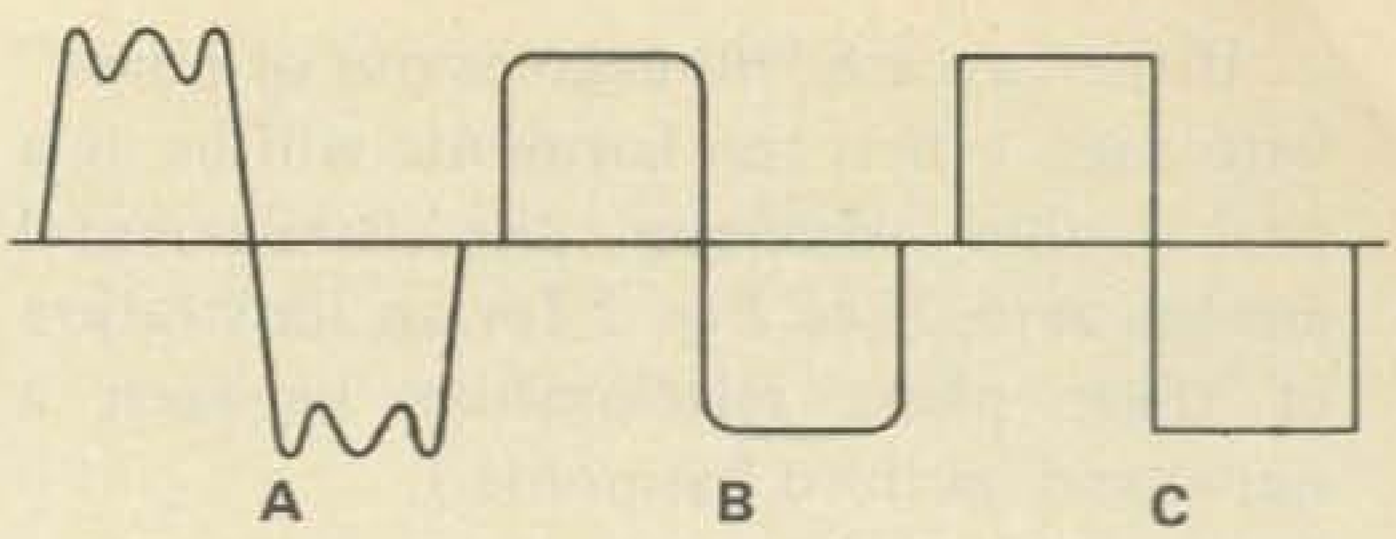


Fig. 5. Square wave can be considered as sine wave together with all its odd harmonics in proper proportions. At left (A) is result when fundamental, third, and fifth harmonics are mixed. Center (B) shows waveform when first 100 odd harmonics are included. Idealized square wave (C) is difficult to distinguish from version produced by first 100 odd harmonics; few scopes would be capable of telling which is which.

To find out how to keep harmonics from coming into existence, let's turn things around and see what we do to encourage harmonics whenever we deliberately want them (because most transmitters do make deliberate use of harmonics, in order to get improved frequency stability).

Deliberate harmonic generation is usually accomplished by circuits known as "frequency multipliers," which look like any other rf amplifiers so far as the schematics are concerned. What makes one generate harmonics for us is the specific manner in which it is operated.

To get a good harmonic generator, we bias the tube's grid much more strongly than for normal amplification, so that its switching action becomes more abrupt; then we apply much more driving power than normal to the stage, again to make the switching as rapid as possible and the output waveform as close to square as we can get.

When we do this, the tube's output signal has a high percentage of harmonic energy, and it's a simple matter to pick off the one we want with a selective (high-Q) resonant circuit. Usually, we take either the second or the third, because it's difficult to get enough power at higher multiples in a single stage. VHF transmitters often use an 8.3 MHz crystal followed by a tripler to 25 MHz and a doubler to 50 MHz, before beginning real power amplification.

Now if we want to generate as *few* harmonics as possible, all we need do is reverse this philosophy. We take special care to bias the tube only enough to get the job done, and to keep driving power at the lowest level capable of producing proper output. The output will then be as free of harmonics as we can get – but they're still present, so our job is not yet done.

If we increase the Q of our resonant output circuit, we will make it more selective and it can reject the harmonics more efficiently. This will reduce the harmonic level at the antenna. In an rf circuit, we can raise Q by increasing the capacitance and then reducing inductance to keep the circuit resonant. Most of the effective resistance of the circuit is in the coil, and so when we reduce inductance we reduce resistance as well. The resistance decreases more rapidly than the reactance, and Q goes up accordingly.

When we have reduced harmonics to the practical minimum by applying these ideas to all straight-through (input and output at same frequency) amplifier stages in a transmitter, we have almost exhausted the possibilities of the first method of harmonic control and it's time to turn our attention to the second – that of bottling up the remaining harmonic energy so that it cannot escape to cause trouble elsewhere.

Before we do so, though, one point needs special emphasis and a couple of tricks with harmonic generators deserve mention.

The point which we must emphasize is that a harmonic cannot be *generated* by anything which does not introduce distortion into the signal, but that the *radiation* of a harmonic can be suppressed by non-distorting devices.

In particular, neither a feedline nor an antenna can generate harmonics if it is in decent working condition; about the only thing in either which could *generate* a harmonic would be a corroded connection. However, if a harmonic is generated back in the transmitter, the feedline and the antenna can easily radiate it to the world – or just as easily can help you keep it contained.

Now for the harmonic-generator tricks. When we use a harmonic generator to double or triple a frequency, we want a single specific harmonic and we don't want any others if we can help it.

As it happens, there's a special type of circuit which can generate even harmonics but suppresses odd ones, and another circuit which generates odd harmonics and cancels out the even ones. Use of these circuits makes life much easier, because the selectivity of the output circuits doesn't have to do so much of the selection job.

The even-harmonic generator is usually called a "push-push" doubler and the schematic appears as Fig. 6. Here's how it works:

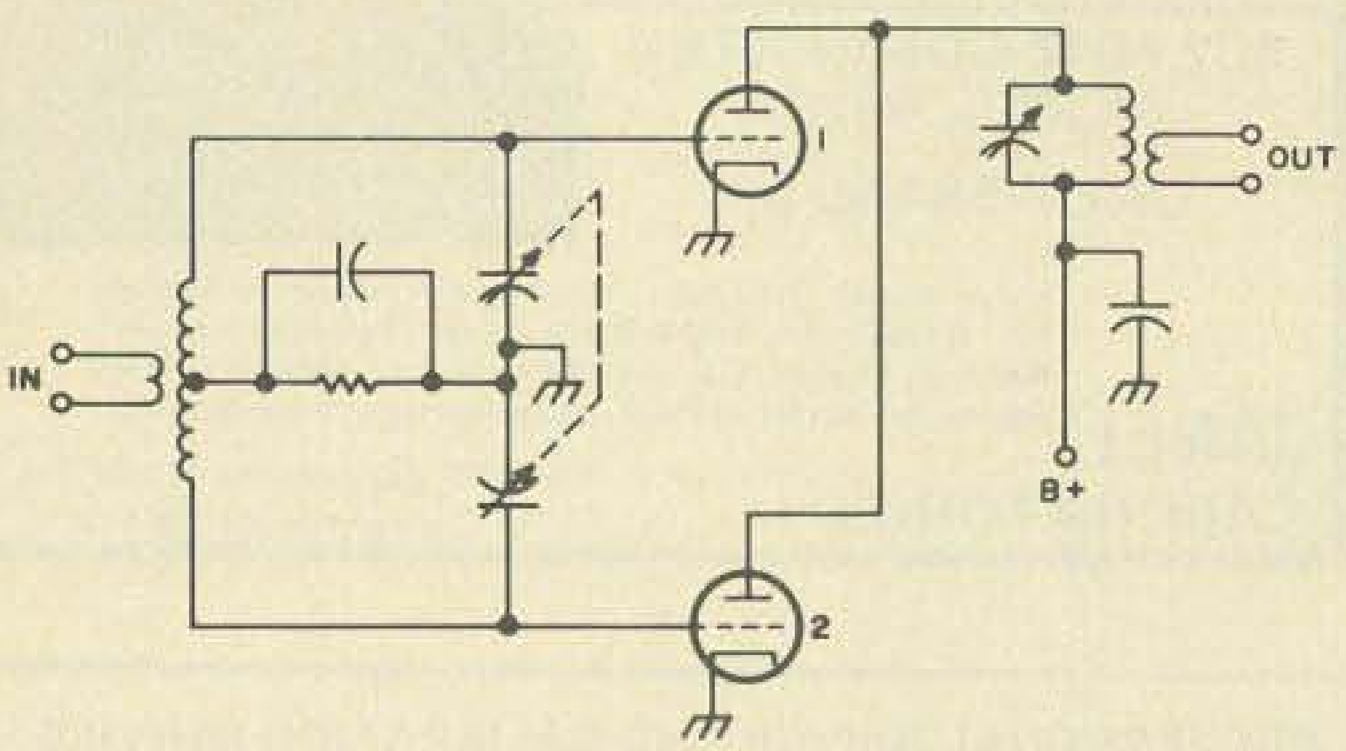


Fig. 6. This circuit, known as "push-push" multiplier, generates only even harmonics of input signal and cancels out fundamental and all odd harmonics.

The centertapped grid circuit divides the input signal into two independent signals, identical in strength but opposite in phase, and applies each to its own amplifier tube. Operating conditions for both amplifier tubes are made identical by the common grid resistance. Outputs at the plates of these tubes will be 180 degrees out of phase with each other at fundamental frequency, but the bias is chosen so that each output also contains an appreciable amount of second-harmonic energy.

These second-harmonic signals are in phase with each other (Fig. 7) despite the out-of-phase condition of the two halves of the fundamental signal.

When both plates are connected, in parallel, to the same tuned circuit, the fundamental portion of the output signal cancels itself out. No such cancellation occurs, however, for the second (or any

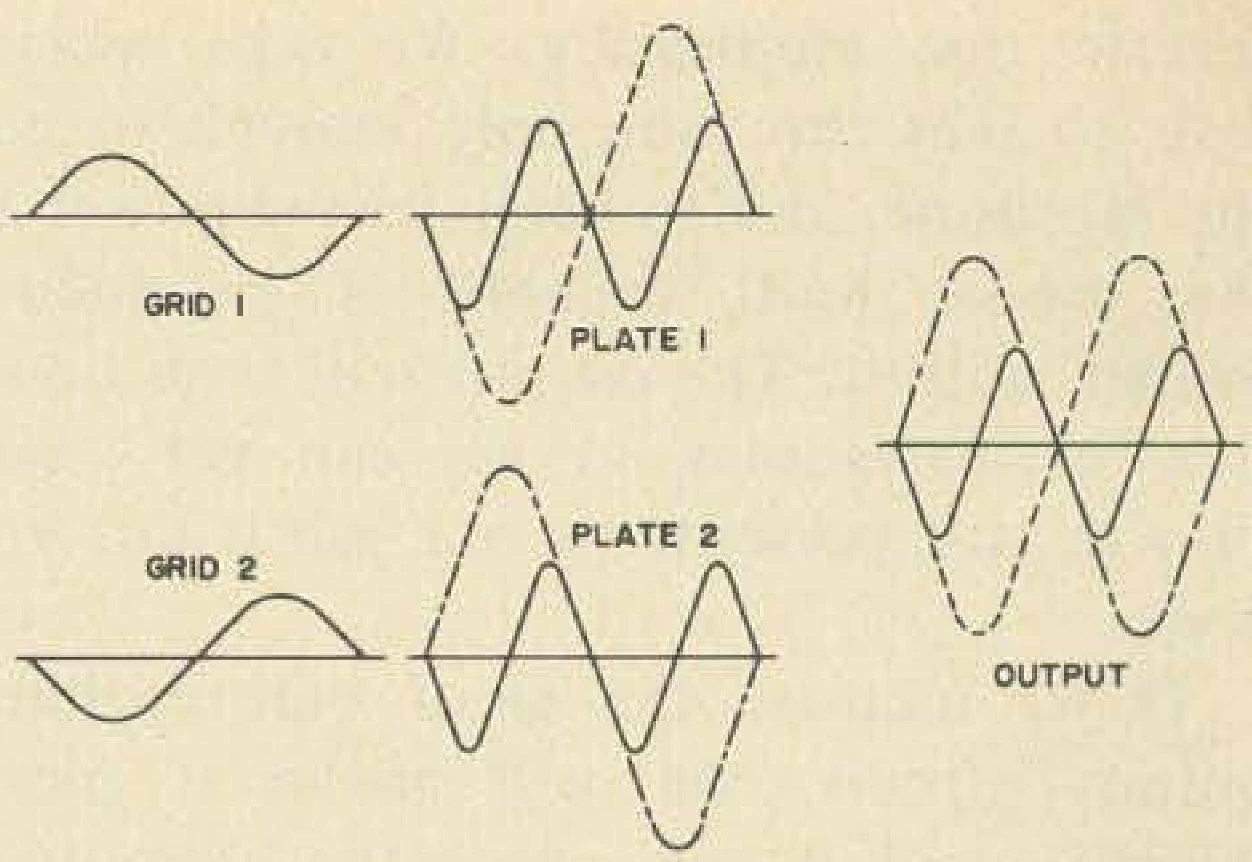


Fig. 7. Input and output waveforms show how push-push doubler works. Grid waveforms, at fundamental frequency, are equal in strength but opposite in phase. Same waveform, only amplified and reversed in phase, appears at plates of tubes — together with second-harmonic component introduced by tube's operating conditions. In output circuit, the two fundamental waveforms cancel each other out, leaving only the second harmonic.

even) harmonic, so by tuning the output circuit to the desired frequency we can recover the even-harmonic energy and couple it out to a later stage.

All odd harmonics are canceled, just as was the fundamental, because they are effectively 180 degrees out of phase with each other at the output.

If we want the odd rather than the even harmonics, a minor modification to the circuit as shown in Fig. 8 does the trick.

The input and amplification action is the same as in the "push-push" circuit. However, rather than the plates being connected in parallel, they are connected to the opposite ends of a "split" circuit which reverses the action of the input circuit, to combine the out-of-phase halves of the signal into a single, in-phase, output.

The recombination is accomplished by effectively reversing the phase of signals from one side, and leaving those from the other alone. This means that the previously in-phase even harmonics are now out of phase with each other, while the out-of-phase fundamental and odd harmonics are pulled into phase.

This circuit is known as the "push-pull" amplifier, because the phase relationships make it appear that half the circuit is "pushing" the signal while the other half is "pulling" it and vice versa. It finds side use as a straight-through amplifier as well as a tripler, and always cancels out even harmonics without effect upon the odd harmonics or fundamental.

When we're trying to reduce harmonic generation to a minimum, use of either a push-push doubler or a push-pull tripler will help; either eliminates at least half the harmonics which might otherwise be generated in a frequency-multiplier stage.

Now let's move on to the other half of the harmonic-control situation and see how to bottle up or contain harmonics which we cannot avoid generating.

The starting point in containment of harmonics is to make it as difficult as possible for them to follow the normal signal-energy route. This means using enough tuned circuits in the normal path, and having adequate selectivity in each, so that harmonics will find it rough going.

To get selectivity we must have adequate "Q" in the resonant circuits. Attempting to get out the last particle of power by loading each stage to its limit or above is a sure way to reduce the Q of its tuned circuits, because Q is among other things a ratio of energy stored to energy released, and when we load a stage we force it to release energy. Harmonic output may skyrocket.

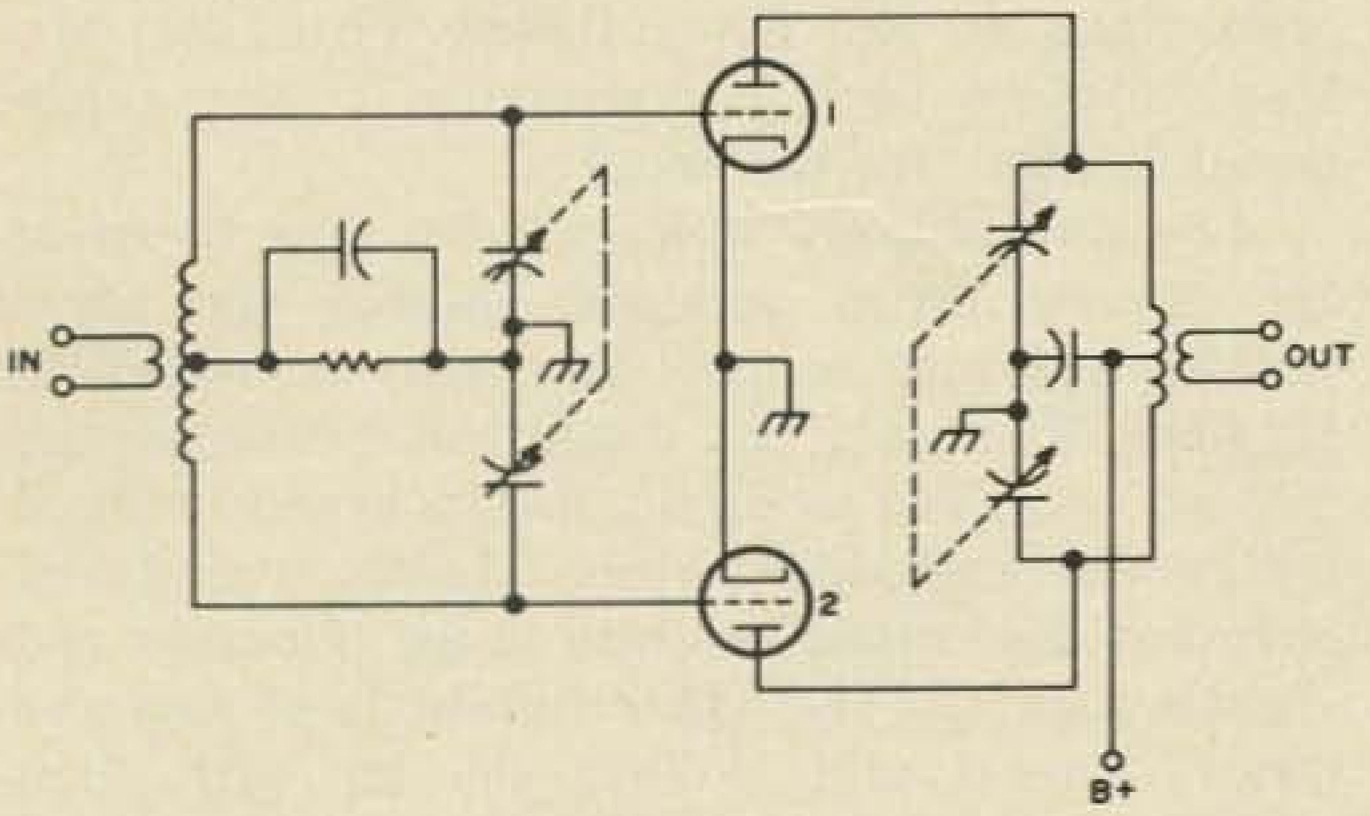


Fig. 8. Push-pull amplifier reverses action of push-push doubler to cancel out all even harmonics while amplifying fundamental or odd harmonics. If plate circuit is tuned to harmonic, it's a frequency multiplier, while if plate circuit is tuned to fundamental, it operates straight through.

Because tuned circuits cost money, and add additional controls which must be adjusted by the operator, many commercial rigs suffer a shortage of tuned circuits in the normal signal path.

We don't recommend redesigning equipment, but you don't have to. You can always add tuned circuits between the transmitter and the antenna by using an antenna tuner, despite the fact that many operators manage to radiate some sort of signal without one.

Another way of keeping down the harmonic output by containment is to be certain the feedline and antenna are well matched to each other, and that the feedline is properly grounded (if coax) or isolated (if open wire or twin lead) to prevent it from radiating on its own.

Proper antenna choice helps minimize harmonics. The popularity of "all-band" antennas helps us forget that any wire which works on 40 meters as well as it does on 80 cannot possibly help you reject the second harmonic of an 80-meter signal. Most "single band" antennas, on the other hand, have such high Q that they refuse to radiate signals at even harmonics of their band. They may perform nicely at odd harmonics, but the antenna tuner can easily take care of that by preventing the third harmonic from getting to the feedline.

When all these points have been covered, the only ways left for harmonic energy to get from the transmitter to the outside are by direct radiation from circuit components, and by conduction through wires which are not carrying the output signal (such as power leads, audio cables, etc.).

Direct radiation can be controlled by completely shielding the transmitter. If adequately done, this will make it impossible for rf to escape except by conduction on wires passing through the shield.

If we then add filters to each wire, to make certain that no energy travels in or on it except that which is supposed to be there, we can be fairly sure all harmonics are under control.

The filters may range from simple bypass capacitors on power lines, to complex arrangements of rf chokes, audio inductors, and capacitors, for lines which carry ac. Bypass capacitors often suffice.

In fact, the normal legal requirements for control of harmonics are usually met without needing to shield and filter the equipment and its connections, but problems with television interference may make some shielding and filtering necessary.

We just mentioned filters – and that was getting ahead of ourselves by a fraction. In the next chapter, we'll go into filters and their action rather deeply, along with impedance matching and solid- state devices. . . . Staff ■

(Leaky Lines cont. from page 12)

ourselves out of business completely.

I want to tell you a little story. A very close and dear friend of mine owned a piece of property out on Long Island, and it had been in his family for generations. It was operated as a fish and game preserve where sportsmen could go and participate in their activities without any crowding or congestion. It was maintained by my friend through his own not inconsiderable resources, together with additional funds contributed by us, the others who used it. All of these were ardent conservationists, and all were fervent in their desire to preserve it and keep it from becoming just another fond, dead memory in a land in which such places are fast disappearing from the scene. All of us who used to wing shoot and angle there were quite convinced that we would succeed in protecting it from outside depredation. We felt that because we were doing what was clearly right, nobody would dream of changing things.

Then along came Mister Robert Moses, the former Parks Commissioner and high mucketymuck from New York City. He decided that this spot would make an ideal addition to the Parks System for the city. He filed for the property in the courts, and started official proceedings to take it over by what is called in law the "Right of Eminent Domain." My friend refused to sell, but in the end, he was literally forced to do so. Mr. Moses represented to the court that he needed to acquire it for the city so that it could be enjoyed by "all the people," instead of just an "aristocratic minority." And he succeeded in convincing the court that if private individuals were permitted to retain control, it would constitute a denial of the rights of the majority, and that this would be undemocratic. So, my friend was forced to relinguish ownership of a piece of prime land to the City of New York, and Mr. Moses lost no time in converting it to a recreational facility "for the people."

The duck blinds which used to line the river are now popcorn vendors, hotdog and pizza stands, and rest rooms. The herd of beautiful Japanese Sika deer has disappeared; so have the mallard, teal, and wood duck. The broad fields of millet and lespedeza which sheltered and fed pheasant and quail are now huge concrete and asphalt parking lots, where hundreds of cars and buses congest and pollute the air with their stinking exhaust fumes. The lovely little stream has literally become a cesspool, for those who bathe in it use it in precisely that fashion. The reverent silence which was unbroken save for the sounds of nature . . . birds, wind, rain, thunder . . . is now shattered by a maddening bedlam of transistor radios playing rock 'n roll, auto horns, screaming teenagers, loudmouthed and contemptuous misfits whose concept of the outdoors is concrete, steel, and glass. The grounds are strewn with fruit rinds, plastic containers, beer cans and bottles, discarded sundries made of liquid latex (the less said about which, the better.) In short, it resembles the beach at Coney Island after a Fourth of July weekend. All in the name of "the people."

This happened because of one principal reason. The courts which swallowed Mr. Moses' grandiloquent plea in behalf of the "people" had absolutely no idea of the far deeper values of that place. They had never been shown. We all thought that they must surely understand the merits of our case by some natural instinct. We thought that anyone would tell the difference between right and wrong. We simply did not reckon with the awesome possibilities.

But nowadays, if Moses (or even Abraham or Isaac) were to try to pull a swindle like that, there would be an outraged outcry that would drown out the sound of Niagara. He would be swept away in the deluge of public indignation. Why? Because we have all been educated in the matter of pollution and conservation. Now we know that we must preserve the priceless heritage of our natural resources against those who seek constantly to exploit them for money, power, political gain, or even for the "people." There are far too many things in American life which have been utterly destroyed on the altar of forced collectivism, and if we are not alert to what is going on, we may find the same thing happening to amateur radio!

All the good intentions in the world cannot compensate for failure by default. Remember that old tale; For want of a nail the empire was lost? The feeble and impotent program of the League with respect to a real campaign of public relations is totally inadequate in representing and safeguarding the interests of almost 300,000 amateurs and the untold thousands yet to come. QST periodically (no pun intended) beats its tired tambourine about public relations. A photo is printed, showing one of our League functionaries posing with a mayor or chief of police or councilman, on the occasion of the unveiling of a bust of Guglielmo Marconi, or the first ham call license plates, or when some two meter hams coordinate the Split Lip, Kansas jug-blowing and Jew's harp tournament. Our activity is not a minor matter, to be treated like the grammar school spelling bee! Amateur radio is not a casual thing to be sloughed off so casually! Anyone who thinks it is, is just kidding himself. We have got to make sure that every legislator in this land is made familiar with the fuller and deeper significance of ham radio, than its use in controlling the floats in the Tournament of Roses, ski tournaments or boat regattas! We have got to make sure that the general public understands that in our ranks there reposes a nucleus of well-seasoned communications personnel, fully trained and equipped to assume vital obligations and duties, prepared to function in cases of national crisis and peril. We must educate Americans so that they will stop thinking of us (if they ever think of us at all) in terms of a bunch of hobbyists, playing around with toys and gadgets. We are not the same as model railroaders, antique collectors, mushroom pickers, bird watchers, weekend golf nuts, rug weavers, skin divers, folk singers, amateur plumbers, hikers or spelunkers! We are not scrabble players or spare time hypnotists and magicians. While we are certainly engaged in an activity which we enjoy, our interest is *not* a hobby! It is a *service!* And don't let anybody, but anybody, ever forget it!

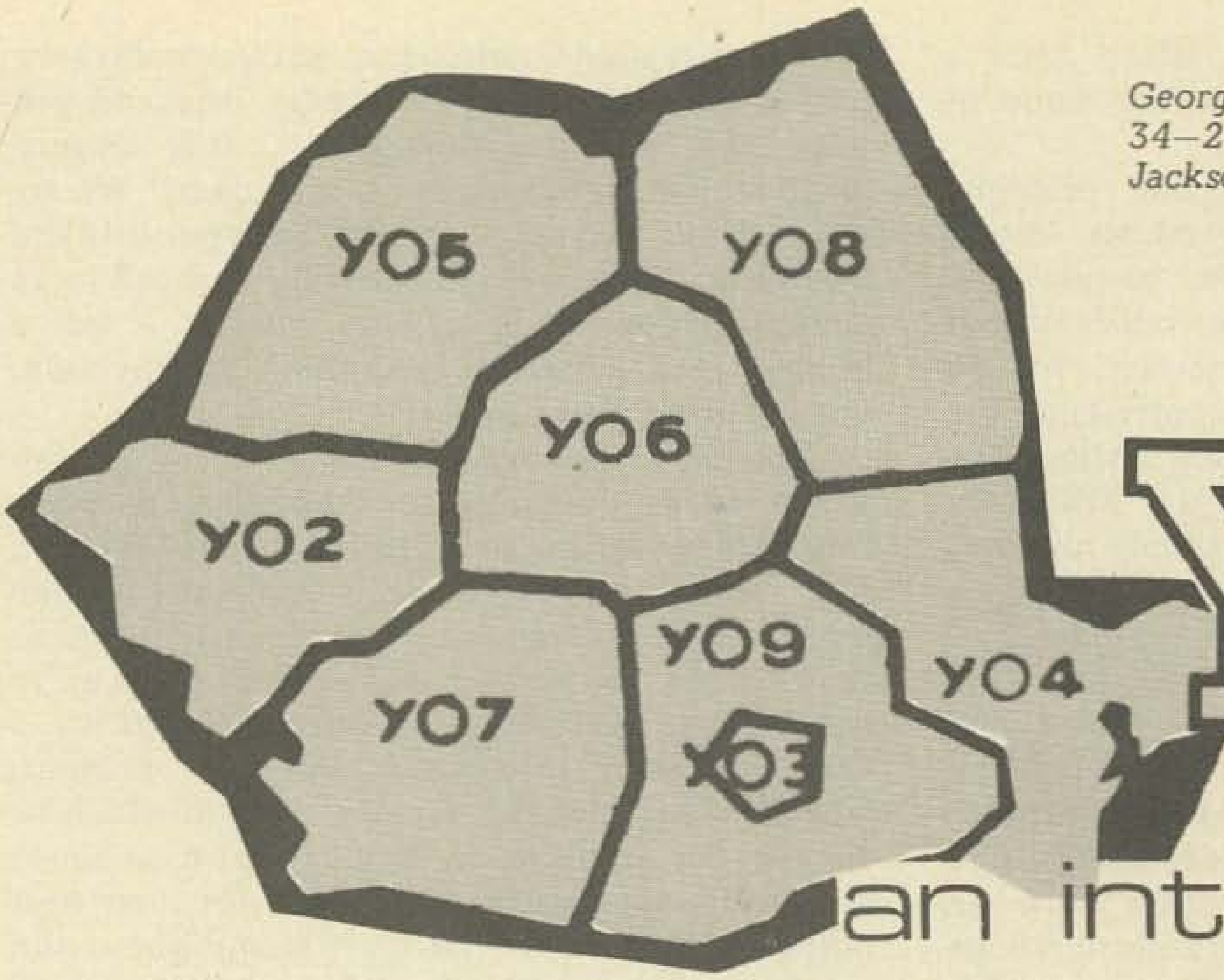
The only way we can begin to do the job which needs doing, is to establish a properly functioning information office in Washington, D.C., with full-time people working at full time jobs, seeking influence in government circles, so that no one can throw a sneak punch while we're not looking. And make no mistake about it . . . there are many interests at this very moment, scheming and plotting, seeking ways in which to destroy our privilege, so they can get their hands on our frequencies, and use them for their own purposes. Any ham who feels secure about the amateur spectrum in today's dog-eat-dog world is either an ostrich or an imbecile! Any ham who would not be willing to bend all his energies and efforts toward insuring the future of amateur radio is either stupid or a scoundrel! And the exact same statement applies to any organization – let the chips fall where they may!

Before World War II, there were many voices which purred softly in our ears, "We don't have a thing to fear from abroad. Why should we waste all our money in order to arm ourselves against an attack which will never come? Our oceans will protect us." Does this sound familiar? Well, the folly of such short-sighted ideas was clearly comprehended, thankfully, and we were able to survive. We did not heed this siren song, chanted by doubletalkers who tried to lull us into a sense of false security, while plotting our destruction at the same time. I do not think that this comparison is at all far-fetched. We are being threatened at this very moment by forces which actively seek to curtail our privilege or limit it. If we do not summon up the will and moxie to fight against these groups, we may soon discover one fine day that we are beyond the point of no return. Then it will be too late to do anything about it.

Can we allow our most prestigious single organization to continue on its present blithe course, denying or minimizing the dire necessity for decisive action, while all of our competitors are consolidating their strength for a stab in the back? For to me, a CB lobby in Washington means only one thing . . . a grab for more frequencies at our expense!

Well, how about it? Isn't it high time and beyond, that every ARRL director and officer be bombarded with mail, instructing him to call for a change in the League's old approach to this vital question? I urge and entreat you to give this your most profound attention and consideration. It may be the very last chance we will ever have. Please think about it. 73. . .K2AGZ ■

George Pataki, ex YO2BO, YO2KAC
34–24 78th Street
Jackson Heights NY 11372



YO an interesting DX

Romania, the YO land, is a beautiful country located in South Central Europe on the Black Sea, north of the Danube. It has wide plains, which are excellent for farming, sheep and cattle raising; hills with large vineyards; and the famous Carpathian Mountains covered with deep forests rich in coal, iron, gold, copper, and salt. The cities, growing industrial centers, have good schools and universities. Romania's oil fields and refineries are known worldwide, as is its nicest region: Transylvania.

Romania has eight amateur districts; from YO2 to YO9. Bucharest, the capital, is YO3. Its neighbors are HA, YU, LZ, UO5, and UB5. In YO-land amateurs are organized by the (Romanian Federation of Radio Amateurs) which maintains a large staff. Some of them are at the central headquarters in Bucharest, but most of them are in charge of the district radio clubs all over the country. The district radio clubs have their own councils which guide the activities of the rest of the clubs in the district, and the individual amateurs.

There are two basic forms of activity; the club and the individual station; co-operation between them is strong and useful for both. In YO-land there are a little over 1200 licensed radio amateurs.

The Club Stations

The club stations are easy to identify; they have a K after the number indicating the district. For example YO8KAN is a radio club in the city of Bacau. The Romanians, being very sociable, love to belong to a club. There they meet friends, operate the club station, do some work in the club's shop, read books or magazines in the library, get advice from the more experienced, or – this is very important – they can boast of the latest DX QSO or show around a rare QSL card.

The main tasks of the district radio clubs, which are financially supported by the government, are to guide, advice, teach, organize, and give material help to the other clubs and individual stations in the district.

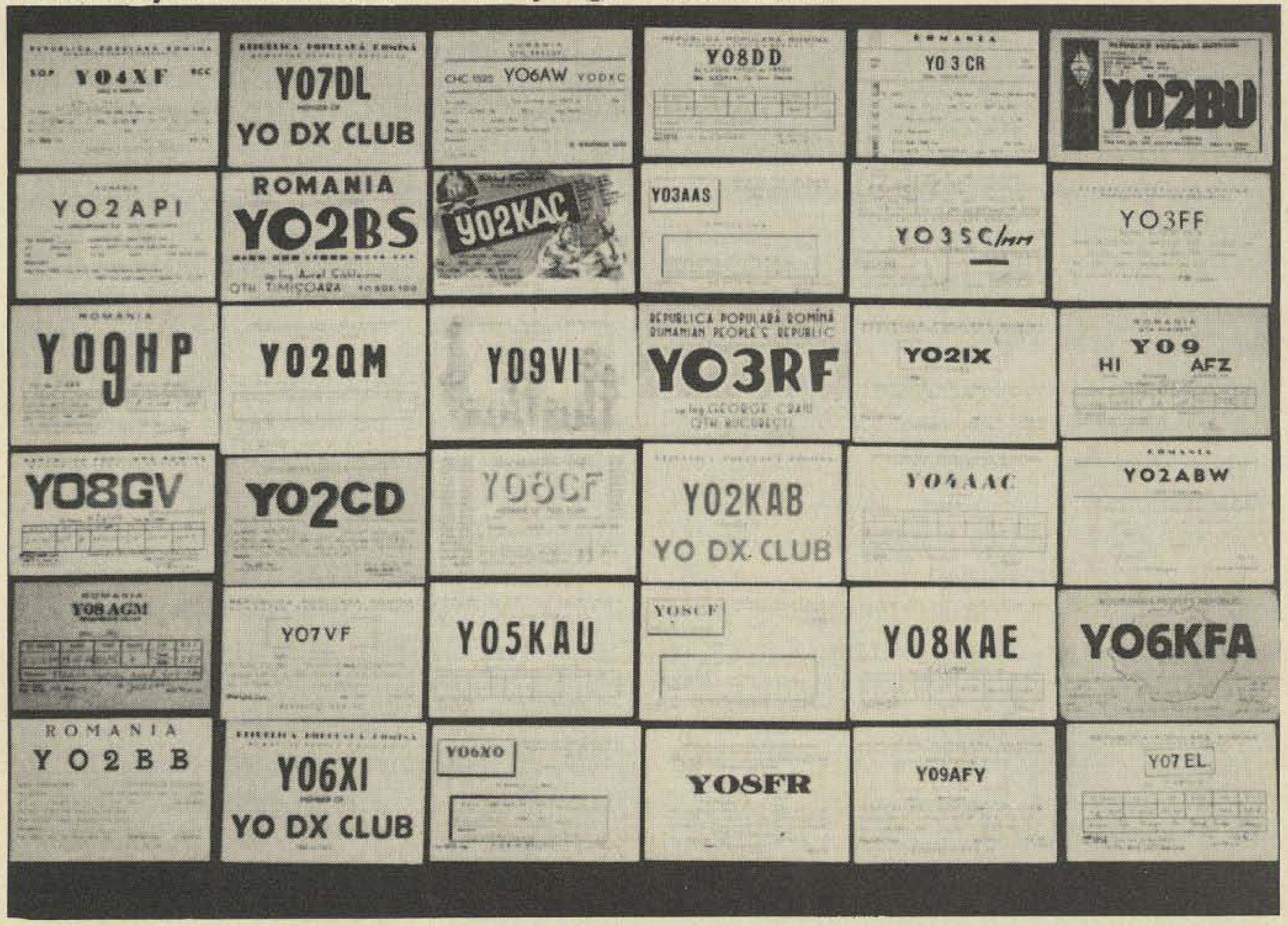
The following district club stations, each having many operators, are very active on the air: YO2KAB in the important university city and industrial center of Timisoara, "the city of gardens"; YO3KSD in Bucharest, the modern capital of the YO-land, YO4KCA in Constantza, the famous port on the Black Sea; YO5KAU in Oradea, the city of hospitality, located in western Romania on the Tisza Plain; YO5KAI in Cluj, the capital of Transylvania, known for its very friendly inhabitants; YO6KAF in Brasov, an 800-year-old town in the heart of the Carpathians, YO6KAL in beautiful Sibiu, an ancient town of medieval appearance; YO7KAJ in Craiova, a large industrial city situated on the Danube plain; YO8KAE in Iassy, the cultural and university center of Moldavia; YO8KGA in Suceava, center of the Bukovina region, noted for its 15th and 16th century monasteries, covered with lovely and authentic frescoes; and YO9KAG in Ploiesti, well-known for its rich oil fields.

In the capital city of Bucharest, YO3KAA is the club station of the Central Radio Club, the headquarters of the Romanian amateurs, and YO3KBN is its second station.

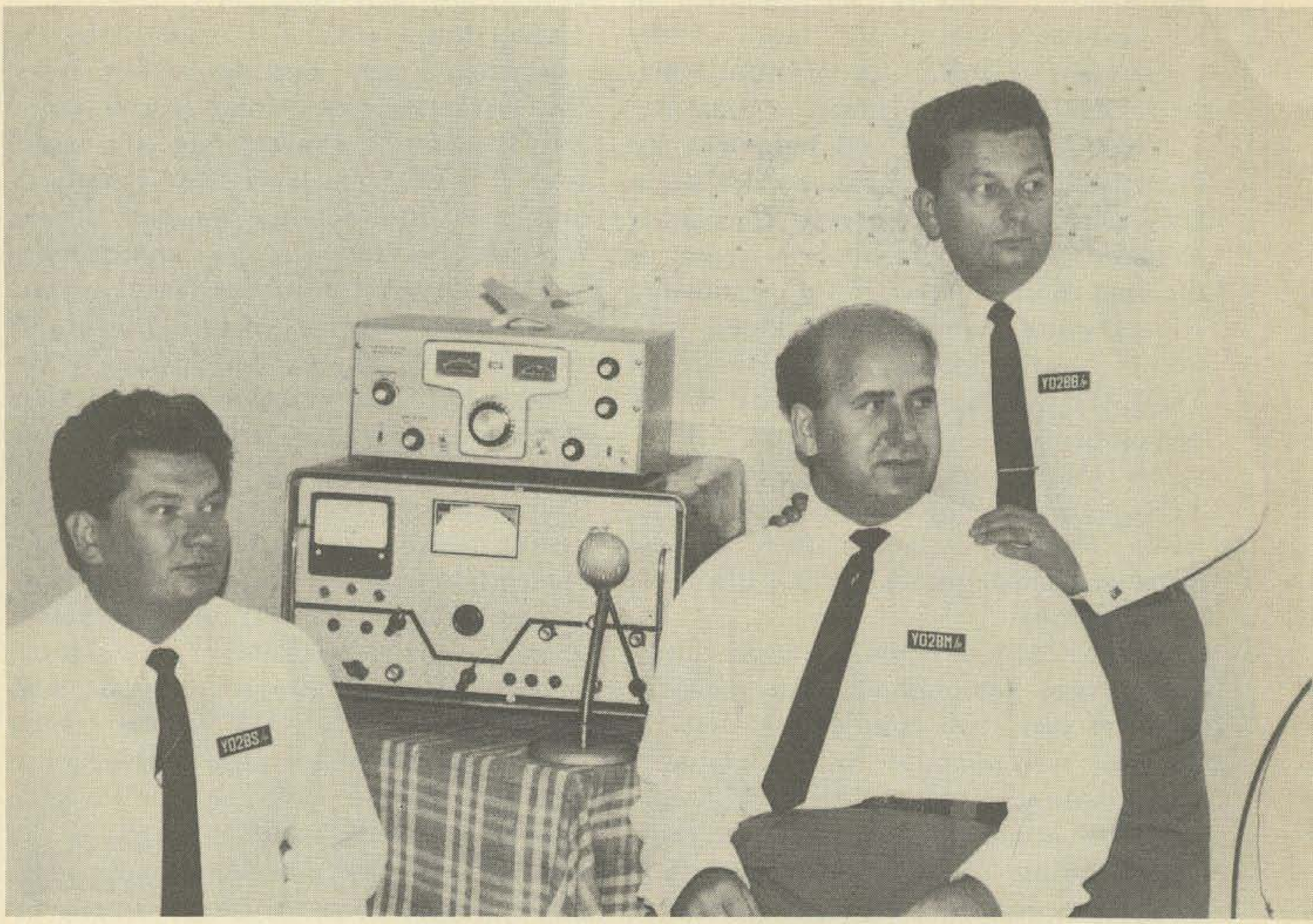
Besides district clubs there are many other clubs. For example, many universities have their own radio clubs. These are generally well-equipped, with a group of enthusiastic students operating the station. YO5KDK is the club station of the Pedagogic Institute of Cluj. After graduation, many of its operators, in love with amateur radio, organize new clubs in the schools where they were sent to teach. Many high schools also have radio clubs. YO4KCE in Galatzi· was built and is operated by the organizing teacher and his best students. The teachers and the parents like to see the kids spending their spare time in a useful way. The students learn basic electronics and code. By operating the club station they are also increasing their knowledge in world geography, in foreign languages, etc.

In every city or village in Romania there is a "pioneers' palace" where the children can learn things normally outside the school cirriculum. YO2KAC, the club station of the pioneers' palace from Timisoara and YO9KDP of Cimpina are operated mainly by young high school students. Under the supervision of their teachers, they also do all the construction work and the maintenance of their station.

Many factories also have amateur radio clubs. For instance, YO3KBC is the station of a large electronics plant in Bucharest; YO5KDL is the radio club of a shoe factory in Oradea, and YO6KEM is the club station of a textile factory near Sibiu. These club stations were built entirely by technicians and engineers employed by those factories.



Some of the Romanian QSL cards received by W, K amateurs.



Aurel (YO2BS) Leo (YO2BM), and George (YO2BB) during their SSB expedition on the peak of the Semenic mountain. The receiver is a Lafayette HA-350 and the transmitter is homemade, built by George.

The Individual Stations

Many club members and operators of club stations also have individual stations at their homes. Some of them began in radio years ago as young pioneers. Mircea, YO2QM, and George, YO3FU, former operators of YO2KAC, are today top DX men. Aurel, YO2BS, who started his hobby as an operator of the district radio club YO2KAB, is now a broadcast chief engineer. George, YO3RF, is an internationally known oldtimer from Bucharest and cofounder of the YO DX Club. He has 260 countries confirmed and received 150 awards and certificates. George is very active on his own station and equally active in club affairs, teaching and helping the new generations of hams.

Cornel, YO3SC/MM, is on the trawler "Constantza." he is working a lot of DX and is visiting personally quite a few of the fellows he contacts. Another very active "Maritime mobile" is Stefan, YO4WV/MM.

Dietmar, YO7VS (ex-OE5ZIM, -OK8AAJ) is a radio technician for the Romanian Airlines in Craiova. He is an excellent DX man but he is more famous for his activity on VHF. On 144 MHz, Dietmar worked with 18 European countries, and his record is 1330 miles.

Using the meteor scatter technique he made 14 QSOs, the farthest with UA1DZ with only 30W input, at a distance of 1134 miles. Presently he is looking for a W–YO moonbounce QSO. Amateurs interested in this kind of experiment should contact him directly: P.O. Box 63, Craiova, Romania.

In Romania, there is a tendency to involve every active ham in club activity. Some teach code, others theory. Some are in charge of the shop or the library or the QSL bureau. Others are with the club station. There are committees for VHF, for field days, for organizing public exhibitions with gear built by amateurs. Other hams are managers for different YO awards and certificates.

A good example of teamwork was

shown in July 1968 by YO2BB, YO2BM, and YO2BS. They installed a rig in a chalet on the peak of the Semenic Mountain, on the southeast corner of the Carpathians. The altitude was 4760 ft; the weather was cold and rainy. But for 10 continuous days, their station worked hundreds of DX stations on 15, 20, and 80 meters. They used a homemade 100W SSB transmitter built by YO2BB, a Lafayette HA-350 receiver, a single-element quad for 15m and longwires for 80 and 20m.

Amateur radio activity in Romania is regarded as a sport and the amateurs are considered sportsmen. They often participate in competitions. The scores obtained on various national and international shortwave contests, code proficiency competitions, the results of the "foxhunts," like the quality in designing and building ham gear, determine the rank of an amateur radio sportsman.

For very high achievements, the National Counsel for Physical Education and Sport could confer special distinctions and honorary titles. A short time ago the following top YO hams received the "Master of Sport" title: Victor, YO6AW, from Brasov; Victor, YO7DO, from Craiova; and George, YO3RF; Petre, YO3FF; Vasile, YO3CR, from Bucharest. Vasile has been a ham since 1948, and has made over 10,000 QSOs. He also has nearly 200 countries confirmed, has more than 180 awards and certificates and is very active in club committees.

The competition among the hams is strong, but friendly. Many times an experienced ham will have around him at the club or in his home a group of youngsters, who help him and learn from him at the same time. The average age of the YO ham is below 30 and the number of licensed amateurs is growing rapidly.

In many tiny villages, as soon as electric power is introduced a beginner will build an amateur radio station. He is usually a teacher, or the agronomist, or the doctor of the village. Soon, others join him and spend their evenings together, watching him making QSO after QSO, then helping him build a new transmitter or install an antenna. And suddenly a new club is born.

YO awards

The Romanian Federation of Radio Amateurs issues 20 different awards, under the following general rules;

- Bands: 3.5; 7; 14; 21; 18 and 145 MHz.
- Mode: CW, AM, SSB, Mixed.
- Mode: CW, AM, SSB, mixed.
- All contacts have to be confirmed by QSL cards, YO cards being in the applicant's possession. Exceptions to this rule may be granted for QSOs made during the international contests.
- YO awards are not issued for various modes, but each class is a separate award.

The application and the log will be sent to: Central Radio Club, Box 1395, Bucharest 5, Romania. The log will be certified either by the awards manager of the association, or by two licensed amateurs, having checked the validity of the QSL cards.

The fee for any award and class is 7 IRCs or $1 (packing and mailing included).

All SWLs may get these awards in accordance with the rules.

The awards will be issued only after the YO stations listed in the application log have received the applicants QSL card. When there are fears that cards have been lost, the applicant is urged to send new QSL cards for the YO hams, together with his application.

Here are some of the YO awards:

YO-ꞁD (Worked All YO Districts). The award is issued for two-way contacts with YO stations located in all YO districts, namely: YO2, YO3, YO4, YO5, YO6, YO7, YO8, YO9.

The award has 3 classes:

- Class 1: for working all 8 districts,
- Class 2: for working 6 districts,
- Class 3: for working 4 districts.

Each YO district worked will be awarded by a specific seal on the certificate.

A district is considered to be fully worked, after two-way contacts with a minimum number of YO stations located in that district, depending on the applicant's location zone, as follows:

YO–AM (YO Alma Mater). This festive award is issued to celebrate the 100th anniversary of Bucharest University.

Location zone	Number of QSOs needed for each district		
	Class 1	Class 2	Class 3
15, 16, 20	10	6	3
14, 17, 21, 33, 34	6	4	2
All other zones	3	2	1
YO hams	15	10	5

A YO station may be worked but once.

YO–AM (YO Alma Mater). This festive award is issued to celebrate the 100th anniversary of Bucharest University.

Depending on his location, the applicant has to gather the following number of points:

Location zone	Needed points	Points scored per contact				
		3.5	7	14	21	28 MHz
15, 16, 20	60	3	1	1	4	8
14, 17, 21, 33, 34	40	4	2	1	3	6
All other zones	20	8	3	1	2	4

Working the same YO station on several bands, the points scored for these contacts will be multiplied by 2 for 2 bands, by 3 for 3 bands, by 4 for 4 bands, and by 5 for 5 bands. For instance: A ham located in zone 33 had 4 contacts with the same station on 3.5; 7; 14; 21 MHz bands. The overall score for these contacts will be: 4+2+1+3=10x4=40 points, which is enough to get the award.

YO–UBZ (Worked Balkans Peace Zone). This award is issued in 3 classes, in accordance with the following rules:

(a) European stations must carry out two-way contacts with a minimum number of countries and districts as follows:

– Class 1: 6 countries and 18 districts
– Class 2: 5 countries and 15 districts
– Class 3: 4 countries and 12 districts including a minimum of 6 YO districts.

(b) Stations outside Europe:

– Class 1: 5 countries and 10 districts
– Class 2: 4 countries and 15 districts
– Class 3: 4 countries and 12 districts including a minimum of 3 YO districts.

Balkan countries and districts considered for this award are:

1. Bulgaria LZ1, LZ2
2. Greece SV
3. Crete SV
4. Dodecanese SV
5. Turkey TA (European part)
6. Albania ZA
7. Romania YO2, YO3, YO4, YO5, YO6, YO7, YO8, YO9.
8. Yugoslavia YU1, YU2, YU3, YU4, YU5, YU6.

The award is also issued for two-way contacts with one YO station, and two different stations in two different countries, on 2m band.

YO–10 x 10 (Worked 10 YO on 10 Meters). There are needed 10 two-way contacts with 10 YO stations on 10m band.

A YO station may be worked but once, regardless the mode of the contact. There are similar awards for all bands (15 on 15m, 20 on 20m, etc.)

YO–DX–C (Worked YO DX Club Members). There are needed two-way contacts with YO DX club members, as follows:

Romanian hams	10 QSOs
Hams in European countries	5 QSOs
Hams in the rest of the world	2 QSOs

The members of the YO DX Club specify this quality of their QSL cards.

Foreign amateurs completing the required conditions for the award during a YO contest, may apply for honorary membership in the YO DX Club.

YO–45–P (Worked Parallel 45). There are needed contacts with radio amateur stations of the countries located on 45th parallel:

North America: W7, WØ, W9, W8, VE3, W1, VE1, FP8

Europe: F, I, YU, YO, UB5, UA1, 3, 4, 6

Asia: UL7, UI8, JT1, BY–BV, UAØ, JA.

Campaigning for ARRL Directors

It's nearing campaign time for directorships in the ARRL, and a lot of good men – and bad – will be actively seeking office. You readers have practically convinced me that the best way to improve the League is from the inside, so maybe an effective group of directors would be the right start.

So . . . how about it? Do you know of any candidates who are especially suited to serve? Or who aren't? Write 73 and give us the lowdown on the prospective candidates in your division.

And how about the directors already in office? How are they performing? You *can* do something. Write your division director a letter and ask how he feels about issues you consider important. Does he think a lobbyist in Washington would help ham radio? How does he feel about incentive licensing? What are his views on repeater rulemaking? About the increase in license fees? Does he plan to put any pressure on the boys at headquarters?

Find out if he keeps informed on League affairs. Ask him if he knows what lawsuits (involving amateurs) the League is helping with. What kind of help is the League offering? How many dollars? How much of the League attorney's time?

You hold a lot of power in your hand as a League member. And you can use it very effectively by telling the whole amateur world which individual you think is best qualified to hold office in your division.

. . . K6MVH ■

Please Use Your Zip Code When Writing 73

– Class 1: 18 contacts with 18 countries

– Class 2: 12 contacts with 12 countries

– Class 3: 6 contacts with 6 countries.

One contact with each country. A YO contact is obligatory in all cases.

Valid contacts: after January 1, 1960

YO–25–M (Worked Meridian 25) There are needed contacts with amateur stations of the countries on the 25th meridian:

Europe: LA, OH, UP2, UQ2, UR2, UC2, UB5, YO, LZ, SV

Africa: 5A, SU, TT8, ST, TL8, 9Q5, 9J2 (VQ2), ZE, ZS1, 2, 4, 5, 6.

– Class 1: 18 contacts with 18 countries

– Class 2: 12 contacts with 12 countries

– Class 3: 6 contacts with 6 countries.

One contact with each country. A YO contact is obligatory in all cases.

YO–20–Z (Worked Zone 20). This award is issued in three classes, for contacts made with amateur stations of the countries belonging to zone 20:

Bulgaria (LZ), Crete (SV), Cyprus (5B4,ZC4), Dodecanese (SV), Greece (SV), Israel (4X4), Jordan (JY), Lebanon (OD5), Romania (YO), Syria (YK), Turkey (TA) as follows:

Location zone	Minimum No. of countries worked Class 1	Class 2	Class 3
15, 16, 20, 21 34	10	8	6
14, 17, 22, 23, 33, 35, 36, 37	8	6	4
All other zones	6	4	2

A YO contact is obligatory in all cases.

YO–5 ON 5 (Worked 5 Continents on 5 Bands). There are needed 5 two-way contacts with 5 DX continents, each on a different band; 3.5; 14; 21; 28 MHz.

The pan pipes are played in Romania's southern provinces (YO3, YO4, YO7, and YO9).

There are 6 continents: Asia, Africa, Europe, North America, South America and Oceania. Own continent does not count for this award.

Additionally are needed a number of YO contacts as follows:

European stations: 3 YO contacts
DX stations: 2 YO contacts

YO–LC (Worked YO Large Cities). There are needed anumber od contacts with YO stations residing in the large cities of Romania:

Bucharest
Alexandria
Arad
Bacau
Baia Mare
Birlad
Botosani
Brasov
Braila
Buzau
Calarasi
Cimpina
Cimpulung Muscel
Cluj
Constanta
Craiova
Deva
Fagaras
Focsani
Galati
Giurgiu
Hunedoara
Iasi
Lugoj
Medgidia
Medias
Oras Gheorghiu-Dej
Oradea
Petrosani
Piatra Neamt
Pitesti
Ploiesti
Resita
Roman
Rosiorii de Vede
Rimnicu-Vilcea
Sibiu
Sighetul Marmatiei
Sighisoara
Suceava
Timisoara
Tirgul Mures
Turda
Tulcea
Turnu-Severin

Only one contact is allowed with each of the cities mentioned above, regardless of band, or mode.

– Class 1: 30 cities
– Class 2: 20 cities
– Class 3: 10 cities

YO–NC (Worked Namesake Calls). This award is issued for at least 5 two-way contacts between partners having the same personal 1, 2, or 3 call letters after the district (or state) figure.

For instance: I1ACD, JA1ACD, LU1ACD, WA1ACD, PY2ACD, etc. The same station may be worked but once.

Radio amateurs having a callsign with two call letters after the figure, must make also a "namesake" contact with a YO station.

Some of these awards are easy to obtain, others are more difficult. It is a worthwhile effort trying to get any of them. Larry, K2UMM, found that he satisfied the requirements for 9 different YO awards. He made up the logs and sent for them right away.

Romanian hams QSL almost 100% and it takes approximately 3–4 months to get these beautiful awards.

In YO land, the hams cannot subscribe to the western radio publications and they are always appreciative when they receive some old copies of 73, QST, CQ or Callbooks.

Romania is a very interesting country. Its natural beauties and the friendliness of its inhabitants attracts more and more tourists. The YO amateurs stretch the rules of hospitality when a foreign amateur visits their country. In a short period of time the following visiting amateurs got the red-carpet treatment: Franco, I1FO, from Milan, Italy; Zbyszko, SP5ZK, from Warsaw, Poland; Janos, Ha5AM, from Budapest, Hungary; Ludwig, DM2CHM, from Leipzig, Germany; Jim, W8FXP, from Jamestown, Ohio; George, K8NEY, from Albion, Michigan; and Lee, W6MNN, from Gridley, California.

Working an amateur in another country is a little like being there. By talking to a ham you can learn about his life, his country, his goals. Why don't you try to learn a little about a far away but interesting land, YO country?

. . .YO2KAC

"Get this, some lid's giving the call UFO!"

"He started building it 3 weeks, 8 blown fuses, two hundred dollars ago."

Neater Cabling with Nylon Cord

The November 1968 issue of 73 contained an article describing some of the fine points of cabling.

After your cabling is complete and the cord ends cut off to 5/8" or so, apply the flame of a match or cigarette lighter. Take care not to burn the cable or components. The *NYLON* will melt very rapidly and form a lump at the junction with the wiring. This will simultaneously accomplish two ends. The lump will prevent the end of the cord from pulling through the knot and loosening the cabling, and at the same time the usual frayed end will disappear into a neater, more finished looking termination.

. . . . **Bill Turner WAØABI**

advised by my lawyers that
ou goons don't ever proofr
you ignored my comments in
I insist that you print ev
should be boiled in oil ov

LETTERS

Repeaters

Your articles and backing for repeaters (FM) and associated operation are great, although your open-repeater-directory was not fully accurate. It was, however, stupendous, and of very effective help during my recent trip across the country and back. Maybe in a year or so, when the FCC gets a decent repeater rules concluded, you can call for info and publish a good, up-to-date list, under separate cover and for $1, with a new directory published yearly. Lots of luck.

Ray Bilger W3TDF

Directories are hard to keep up-to-date, but we're trying. The update currently being prepared has more than 100 new repeater entries plus about 100 changes in existing relays.

. . . Ken

Propagation

Please convey my thanks to your propagation analyst, Mr. John Nelson. His successive forecasts of three poor Sunday's in a row have been 100% accurate from this QTH. So thanks for this service. . .very much appreciated.

Neil Johnson W2OLU
74 Pine Tree
Tappan NY

Our analyst has received national acclaim and many honors for his predictions, many of which baffled even government experts.

. . . Ken

Favoritism

Rev. Peter Gonos (K6GZN) takes the FCC to task for not giving a blind person special consideration ("Letters," June 1970). I agree that the examiner was a grouch, but publishing vague accusations is not the way to handle this situation. Public servants with a public-be-damned attitude can be removed from contact with the public if one complains in the right places. I assume K6GZN could name names, place, time, and other pertinent facts.

Robert Newman WA7IEH
Box 283
Estacada OR

Censorship

When I picked up a copy of the FM Repeater issue of 73 at a local ham store, I was very favorably impressed.

I then noticed a column which mentioned the writer's objection to Latin America-to-Miami phone patches (he'd rather that *he* use the frequencies). Well, he's entitled to his opinion, though I'd say DX phone patching is "more important" than DX ragchewing.

He then goes on to suggest (very obliquely, of course) that we ship the Latin Americans in the

Miami area back where they came from. He thus shows his ignorance of what belongs in an amatuer radio magazine, and, perhaps, of what it means to be an American, and what makes this country great.

Anyone who could write something like that is beyond reaching, but where was the editor? I hope to see a retraction in a future issue of 73, so that I may, in good conscience, subscribe to what appears to be an excellent radio magazine, when it sticks to that area.

Michael Gershman WA3OOB
11550 Stewart Lane
Silver Spring MD

You are calling for censorship. . .are you really in favor of that? Do you really feel that I should not print things in 73 that I do not agree with? 73 prides itself for its policy of publishing all intelligent sides to various issues.

. . . Wayne

Feedback

The following is an adaptation of an experiment common in most basic college physics courses.

There is an easy way to automate the comparison of light intensities used in K1CLL's wattmeter. (August 73) Mount the two bulbs rigidly and place a small square of shopping bag paper, which has a spot marked in the center, with margarine or some other light oil, exactly equidistant between the two bulbs. When the bulbs have the same intensity, the spot on the paper will seem to disappear. The paper must not be exposed to strong external sources during measurements. This method should also greatly increase accuracy.

Alan P. Biddle WA4SCA/7
Box 10866
Tuscon AZ

The League and 73

I notice you punching up the ARRL which I think needs to get up with times. I don't subscribe to QST; for one reason, it costs too much for the couple of writeups I could get some use out of once in a while. The rest of the magazine is filled with contests and League doings, and when you save a pile of QST you got about 9 times as much paper as you need to fumble through to find something on that antenna or what have you. I do think ARRL is doing a good job on the code practice sessions and I do think that our extremists should quit QRMing that session each night for the short time they are on. After all, they have been doing it for years now so the oldtimers should know it's there.

Orville Gulseth W5PGG
1435 King St.
Clarksdale MS

Moonbounce

Anyone in Chicago/South Bend area working on moonbounce? Would like to contact others who share my interest.

Phill Chasey WA9GAA
506 W. Angela Bl
South Bend IN

License Courses

While waiting on the FCC to send my Novice license to me I haven't let any grass grow under my feet in preparing for the General class examination. Having had some electronic instruction at Fort Monmouth back in my Army days, I have concentrated mostly on the code, believing that the theory wouldn't take much effort. I have been brushing up on theory for quite some time by studying an NRI course, supplemented with a couple of AMECO books and several of those published by the ARRL. It would seem that this would be sufficient preparation for the FCC exam. However, I will have to admit that I have never *really* understood some of the very basic principles of electricity and electronics and I have been relying on my ability to memorize what I have repeatedly studied, hoping that someday the understanding would finally dawn.

Last weekend I stopped by the local electronics store to pick up a copy of QST and I happened to notice on the cover of 73 that here was a new study series on getting the General ticket, so I bought both the July and August issues. I can't explain what a stroke of good fortune this has turned out to be for me. I had just about decided that thorough understanding of electronic and electrical theory required some natural ability that I happened to be born without.

Thanks to 73 I now have a much better understanding of the relationship of circuit components, voltage and current in electrical circuits, and that of resistance versus reactance. Looking back on the past, I can see that my particular problem has been that when I would read something I didn't quite clearly understand, I would skip through that section of the material with a vague idea of what the writer was trying to convey and go on to something easier to comprehend. This, obviously, has hindered my ability to approach new knowledge with comparative ease.

More specifically, I have been able to understand how each electrical component works by itself and have learned the characteristics of various circuits, but I have always had trouble understanding the interaction of the components of circuits and the formulas used to arrive at answers to required values. I am anxious to study the next installment and I feel that when I take the exam for the General ticket I will be grateful to 73 for giving me a sorely needed lift.

Having gained from studying this material, I began reading some of the other articles in the two issues and have discovered that 73 is the most refreshing ham publication I have read. To a beginner it is a big help to know that someone is interested in his efforts to become an amateur and willing to be of help, rather than taking the attitude that amateur radio is for a selected group in which membership is by invitation only.

John Leach
Metairie LA

Hobby License

Apparently your left hand does not know what your right hand does! I refer to your coupon asking that the FCC give up the 220 MHz band to a hobby type service requiring no examination.

In your editorial you make the statement, "Since the ARRL has set aside $100,000 for the defense of our amateur frequencies it seems logical to me that it is up to them to make a definite move in this direction." Can you explain to me whi in one statement you indicate the ARRL is not defending our frequencies to the utmost, yet in another portion you are attempting to give away one segment of our frequencies to a group of people in the same category as the CB'ers?

You indicate in your Action Coupon, "Amateur radio has been stalled for seven years now. . ." Apparently you have not participated in the hobby of amateur radio for seven years because I can hardly see indications of amateur radio being stalled. It would seem to me that amateur radio has made more progress in the last ten years than they had in the preceding ten years.

I cannot see how giving 220 MHz to a group of people without examination could correct the present chaotic conditions in CB. If you will think back a few years you will remember citizens radio originally was in the 450 MHz band and was used very little by CB'ers.

Robert Johnson WA∅ PVW
5544 Blue Ridge Blvd
Raytown MO

The proposal is not to GIVE part of 220 away. It is to USE part of 220 to attract more hams. For the past seven years the number of new amateurs has been declining.

. . . Ken

FM Calling Channel?

The frequency must of course be one not presently used, or used by the least number of persons. I would suggest that 146.910 be considered.

Robert S. Katson W1HBH
59 Meadow Brook Dr.
Monroe CT

Do we really need it? 146.94 is admittedly a national repeater output frequency, but it IS monitored by just about everyone on FM. FM'ers in repeater areas can operate through their local systems and get a contact almost anytime, particularly where there is an emergency. Where there is no repeater, there is still .94. When it is so easy to contact another station on .94, why try to set up another channel – one that probably wouldn't be monitored anyway? Repeater transmissions are usually kept short enough to *allow any user to get in within a minute or less. And if users get out of the habit of "tail-ending" other users, a brief monitoring period would be available at the end of each station's transmission. Who could ask for a more efficient emergency communications setup?*

. . . Ken

Article Policies

Some other ham magazines may take years to pay for an article, but you guys are something! You paid me $20 for a short article which you never printed (sent to you 1 year ago).

Gabe Gargiulo WA1GFJ
160 Elm
North Haven CT

We liked your article and bought it. Now it's working its way toward the top of the heap.

. . . Ken

From the Lunatic Fringe. . .

I have been reading your magazine for many years and have enjoyed it but I never felt that your comments on the ARRL, and your advice and insinuations were in good tast or even good sense.

I do feel that you are doing ham radio and hams a great injustice, since your attacks on the ARRL do incite the lunatic fringe that has infiltrated ham radio, and these degenerate vicious slobs play such tricks as jamming of the CW practice sessions, hurting new hams or potential hams who are trying to get that code practice, which is being denied them. In short, this is at least one of several forms of damage and injury, your tirades may be responsible for. Only the lunatic fringe and the weak minded would respond to those articles and only in the modes I have mentioned.

Also I noticed that when that gang of long-haired cowards utilized the college radio clubs to propagate their destructive and idiotic policies on the air and on ham bands, those who wrote to your magazine and objected to same were answered with jeering and smart alecky retorts. If you don't think that such use of the ham bands *could* very easily result in total loss of ham privileges, you are not fit to be running a ham magazine.

I have decided not to renew my subscription, and if enough of us oldtimers feel the same about it, you may find yourself going into bankruptcy, unless of course, you are being financed by Russia, Cuba, or dope sales.

Jacob Dubrusky W2LVR
Box 482, Flushing
Queens, NYC NY

Good Grief! *. . . Ken*

Code

I have been reading with great interest the comments by some hams about the new licensing requirements. . .particularly about code requirements. I would very much like to become a ham operator. Only one thing keeps me from fulfilling that desire: CODE.

I have spent endless hours trying to acquire a code speed sufficient to get a license, but have never been able to pass the test. At one time I received three hours of code training daily, five days a week for six months; but at the end I could not pass a 16 wpm test.

However, I would make a good ham operator, as far as technical ability is concerned. I have held a First Class radiotelephone license for over 25 years. During that time I have been actively occupied in radio and electronics, in many different areas. The technical test would be no problem and I might even contribute some worthwhile ideas to ham radio.

I don't believe that code will ever completely die out, but it has been replaced in many ways with other types of transmissions. Now you can even buy an automatic code sender that will convert typed characters to code equivalents. Very little would be lost to the ham world if noncode operators were licensed. Those who wished to operate with code could pass a supplemental code test.

But please let's not keep up the howl... "anyone can pass the code if they really try," because I have really tried – and can't!

Ernest T. Robarge

Satisfied Lifer

The time has come for another auto de fe. Please enroll my second son for life, for which I enclose $50. You might be interested to know that this is the third lifetime subscription to your magazine I've given away. The idea is to lure the recipients into the more technical end of the sport.

F.M. Burton

73 Reader Service Coupon

Now we don't say that every single reader must buy every last product advertised in 73. We believe that, but we don't say it. The very least every reader can do is to put on a show of interest in the products herein advertised. To make this a simple task, even for the laziest reader (now there is a contest for you!), we have cleverly arranged the advertising index to double as a readers service coupon. All you have to do is tear it out (or photocopy it) and send it in with the appropriate boxes marked. (We have a prize for the most boxes marked . . . a silent prayer of thanks from the publisher). We'll accept postcards, slips of paper, or almost anything else that lists the companies you want to hear from and your address.

No one likes to go into a store without buying something, right? It is the same with these information requests. You will be expected to buy something. Oh, it doesn't have to be a $50,000 antenna system, but it should be something modest . . . a transceiver . . . a linear . . . you know. We'll leave the decision up to you, knowing that we can trust you to do the right thing.

And we are definitely not saying that the use of this service coupon has any curative powers, but we cannot but notice that many readers report remarkable relief from simple backache, headaches, lumbago, and acid indigestion after sending in their coupon. Why take any chances?

MAIL TO 73 Inc., Peterborough NH 03458

Name ______________________

Call ______________________

Address ______________________

______________ Zip ______________

PROPAGATION CHART
J. H. Nelson
Good O Fair (open) Poor □

October 1970

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

EASTERN UNITED STATES TO:

GMT:	00	02	04	06	08	10	12	14	16	18	20	22
ALASKA	14A	14	7A	7	7	7	7	7	14	14A	21	21
ARGENTINA	21	14	14	14	7	7	14A	21A	21A	21	21	21
AUSTRALIA	21A	14	7B	7B	7B	7B	7B	14B	14	14	21	21
CANAL ZONE	21	14	7A	7A	7	7	14	21A	21A	21A	21A	21A
ENGLAND	7	7	7	7	7	7A	14A	21A	21A	21	14	14
HAWAII	21	14	14B	7B	7	7	7	7B	14	21	21A	21A
INDIA	7B	7B	7B	7B	7B	7B	14	21	14	14	14	7B
JAPAN	14	14	7B	7B	7B	7	7	7	7B	7B	7B	14A
MEXICO	21	14	7	7	7	7	14	21	21	21	21A	21A
PHILIPPINES	14	14	7B	7B	7B	7B	7B	14B	14	14	7B	14
PUERTO RICO	14	7	7	7	7	7	14	21A	21A	21A	21	21
SOUTH AFRICA	14	7	7	7B	7B	14	21A	21A	21A	21A	21	21
U. S. S. R.	7	7	7	7	7B	7B	14	21A	21	14	14	7B
WEST COAST	21	14	7A	7	7	7	7	14	21	21	21A	21A

CENTRAL UNITED STATES TO:

GMT:	00	02	04	06	08	10	12	14	16	18	20	22
ALASKA	21	14	14	7	7	7	7	7	14	21	21	21
ARGENTINA	21	14	14	14	7	7	14	21A	21A	21	21	21
AUSTRALIA	21A	21	14	7B	7B	7B	7B	14	14	14	21	21
CANAL ZONE	21	14	14	7A	7	7	14	21	21A	21A	21A	21A
ENGLAND	7	7	7	7	7	7B	7A	14A	21	21	14	14
HAWAII	21A	21	14	14B	7	7	7	7	14	21A	28	21A
INDIA	14	14	7B	7B	7B	7B	7B	14	14	14	14	7B
JAPAN	21	14	7B	7B	7B	7	7	7	7	7B	14	21
MEXICO	21	14	7	7	7	7	7	14	21	21	21	21A
PHILIPPINES	21	14	14B	7B	7B	7B	7B	7B	14	14	14B	21
PUERTO RICO	21	14	7	7	7	7	14	21	21A	21A	21A	21
SOUTH AFRICA	14	7	7	7B	7B	7B	14	21A	21A	21A	21	21
U. S. S. R.	7B	7	7	7	7B	7B	7B	14	14	14	14	7B

WESTERN UNITED STATES TO:

GMT:	00	02	04	06	08	10	12	14	16	18	20	22
ALASKA	21	14	14	7	7	7	7	7	7A	14	21	21
ARGENTINA	21	21	14	14	14	14	7B	14A	21A	21	21	21
AUSTRALIA	28	28	21	14	14	7B	7B	7B	14	14	21	21
CANAL ZONE	21A	14	14	7A	7	7	7A	14A	21A	21A	21A	21A
ENGLAND	7B	7B	7	7	7	7B	7B	14	14	21	14	14B
HAWAII	28	21A	21	14	7A	7	7	7	14	21A	28	28
INDIA	14	14	14	7B	7B	7B	7B	7B	14	14	14	7B
JAPAN	21A	21	14	7B	7B	7	7	7	7	7B	14	21
MEXICO	21A	14	7	7	7	7	7	14	21	21	21	21A
PHILIPPINES	21A	21A	21	7B	7B	7B	7B	7B	14	14	14	21
PUERTO RICO	21	14	14	7	7	7	7	14A	21	21	21A	21A
SOUTH AFRICA	14	14B	7	7B	7B	7B	7B	14	21	21A	21A	21
U. S. S. R.	7B	7B	7	7	7B	7B	7B	7B	14	14	14	7B
EAST COAST	21	14	7A	7	7	7	7	14	21	21	21A	21A

A = Next higher frequency may be useful also.
B = Difficult circuit this period.

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