

CQ Reviews:

The EBC-144 JR.

2 Meter FM Transceiver

BY NORMAN STERNBERG,* W2JUP

It is rare that this writer gets the opportunity to evaluate a piece of equipment offering a real challenge to one's measurement ability. But this is one of those occasions. The equipment in question, the EBC-144 JR, produced by the Emergency Beacon Corporation, of New Rochelle, New York, is state-of-the-art in both design and execution. Following the appearance of several external synthesizer units on the market, the EBC-144 JR. is the first 2 meter f.m. radio to appear, complete with synthesizer and medium-power amplifier all in one very smartly designed professional-looking package. It has the physical aspect of commercial avionics equipment rather than ham gear, and although intended for amateur service has some performance characteristics that I would like to see in aircraft radios.

The Circuit

Figure 1 is a simplified block diagram of the transceiver. Signals from the antenna flow through the solid-state switch to the first r.f. amplifier. This consists of two low-noise, wide dynamic range 3N140 fet's, providing about 20 db gain with five poles of bandpass filtering over the 144 to 148 MHz range for the reduction of spurious, image and cross modulation products. This two stage r.f. amplifier feeds a 3N341 dual-gate mixer, which in turn feeds an 8 pole crystal filter at 10.7 MHz, with a 6 db bandwidth of 13 kHz. This is followed by a two stage i.f. amplifier using a pair of 2N3563s with about 30 db of gain and a low noise figure. Then, a 2 pole crystal filter also at 10.7 MHz, again with a bandwidth of 13 kHz. The output of the 2 pole filter drives a CA3089E IC which provides the necessary f.m. limiters and detector, as well as a signal strength output for an S meter. The recovered audio feeds a noise-operated audio squelch module and then a uA706 IC audio amplifier furnishing about 5 watts of audio to the internal speaker and the external speaker jack.

The dual-thumbwheel synthesizer chain controls a VCO operating in the 133.3 to 137.3 MHz range for receiving, and in the 144 to 148 MHz range for transmitting. The VCO is directly modulated by the input audio signal for



The EBC-144 JR. measures 6 $\frac{5}{8}$ W. x 2 $\frac{7}{8}$ H. x 11" D. excluding knobs and feet and weighs in at 6 pounds including mounting bracket. Front panel controls are self evident from the photo and are explained further in the text. The buttons on either side of the Mode switch are indicator lamps to show which set of thumbwheel switches are in use.

legitimate f.m., while its output feeds the transmit chain and loop mixer via an isolation amplifier. The VCO signal is heterodyned with either a 119.3 MHz signal for receive or a 132 MHz signal for transmit. The output of this mixer is a lower frequency signal in the 12 to 16 or 14 to 18 MHz range.

A variable frequency divider divides the 12 to 16 or 14 to 18 MHz signals down to approximately 5 kHz. This 5 kHz signal is then compared in a phase detector with a very stable 5 kHz reference signal to produce a d.c. error signal related to the difference between the divider output and the reference. This d.c. error signal is filtered to remove the 5 kHz component and applied to the VCO for frequency correction.

The divide ratio of the variable divider is determined by the settings of the thumbwheel switches, and/or by the Mode switch setting. The variable divider is a counter which is preloaded with a number from 1400 to 1800 and counts down to zero for receive and 200 for transmit. To achieve an offset for repeater operation the divider is programmed to count down to a different number: 140 for +600 kHz offset; 260 for -600 kHz offset. Each count changes the transmit offset by 10 kHz. The counter is followed by a flip-flop which further divides the counter output by two giving a total divide ratio of 2800 to 3600. Programming an additional count at this point produces

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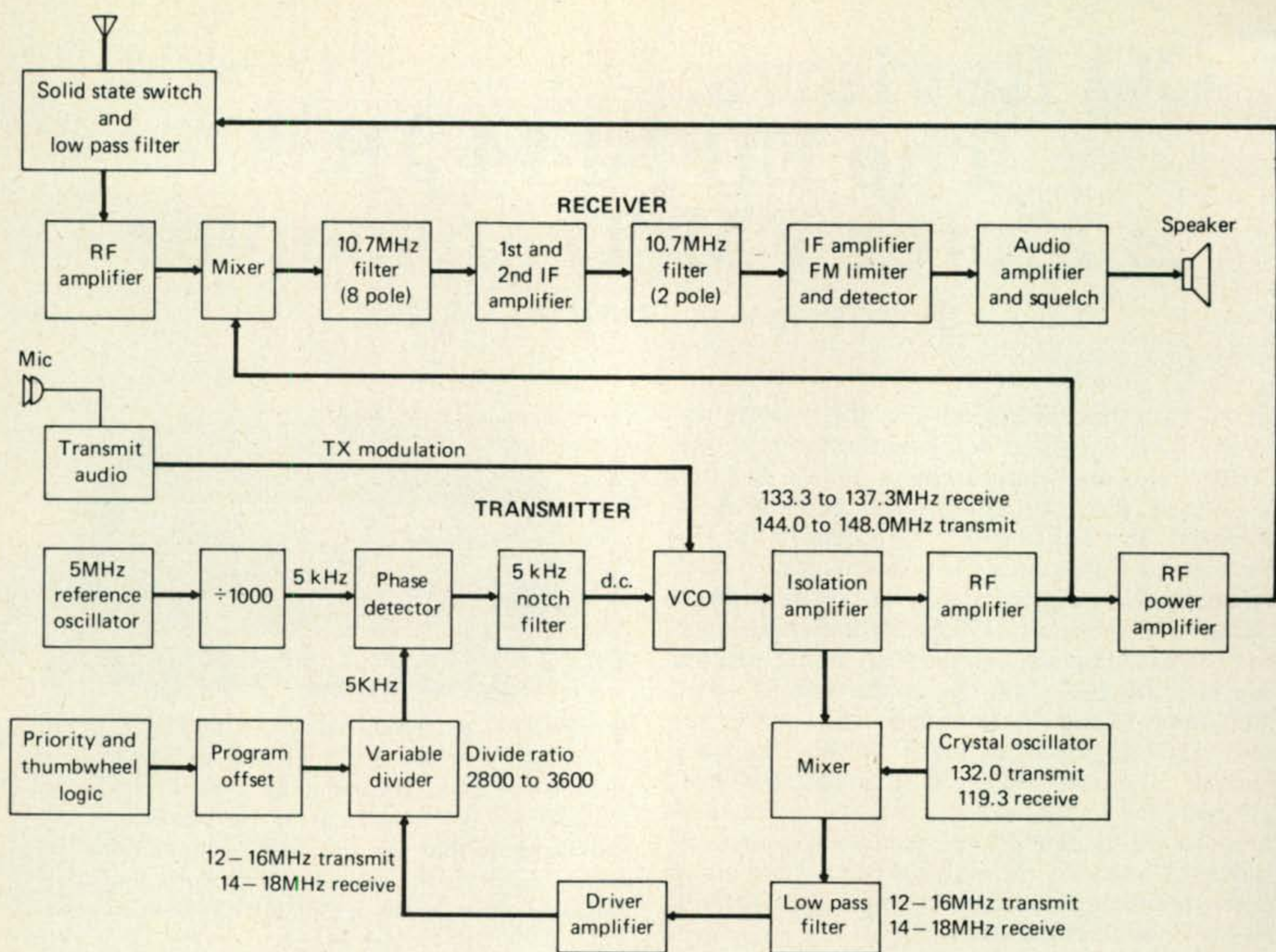


Fig. 1—Block diagram of the EBC 144 JR. showing the frequency synthesizer scheme.

a 5 kHz increment in the VCO's frequency. The technique of pre-programming the counter and counting down to 140, 200 or 260 is termed "Early Zero Sensing" by EBC, and permits the use of greatly simplified logic, with the thumbwheel switches programming the counter/divider directly without the use of diode matrixes, etc.

The output of the VCO is amplified and drives a 2N4427, then a 2N6080 driver stage, which feeds the 2N6082 final amplifier to an output of nominally 20 watts. The output stage feeds a solid-state antenna switching network and a three-section low pass filter and matching network.

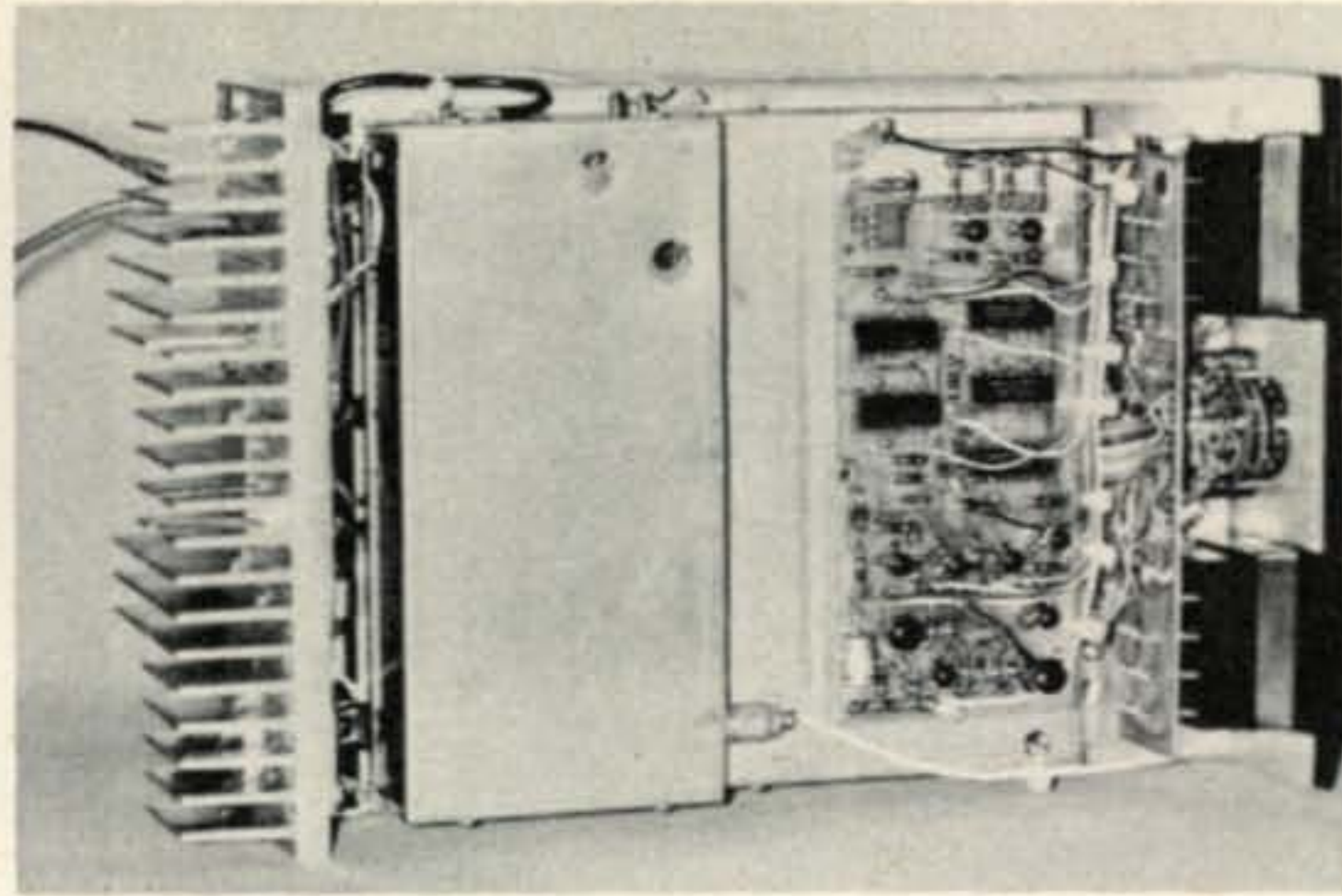
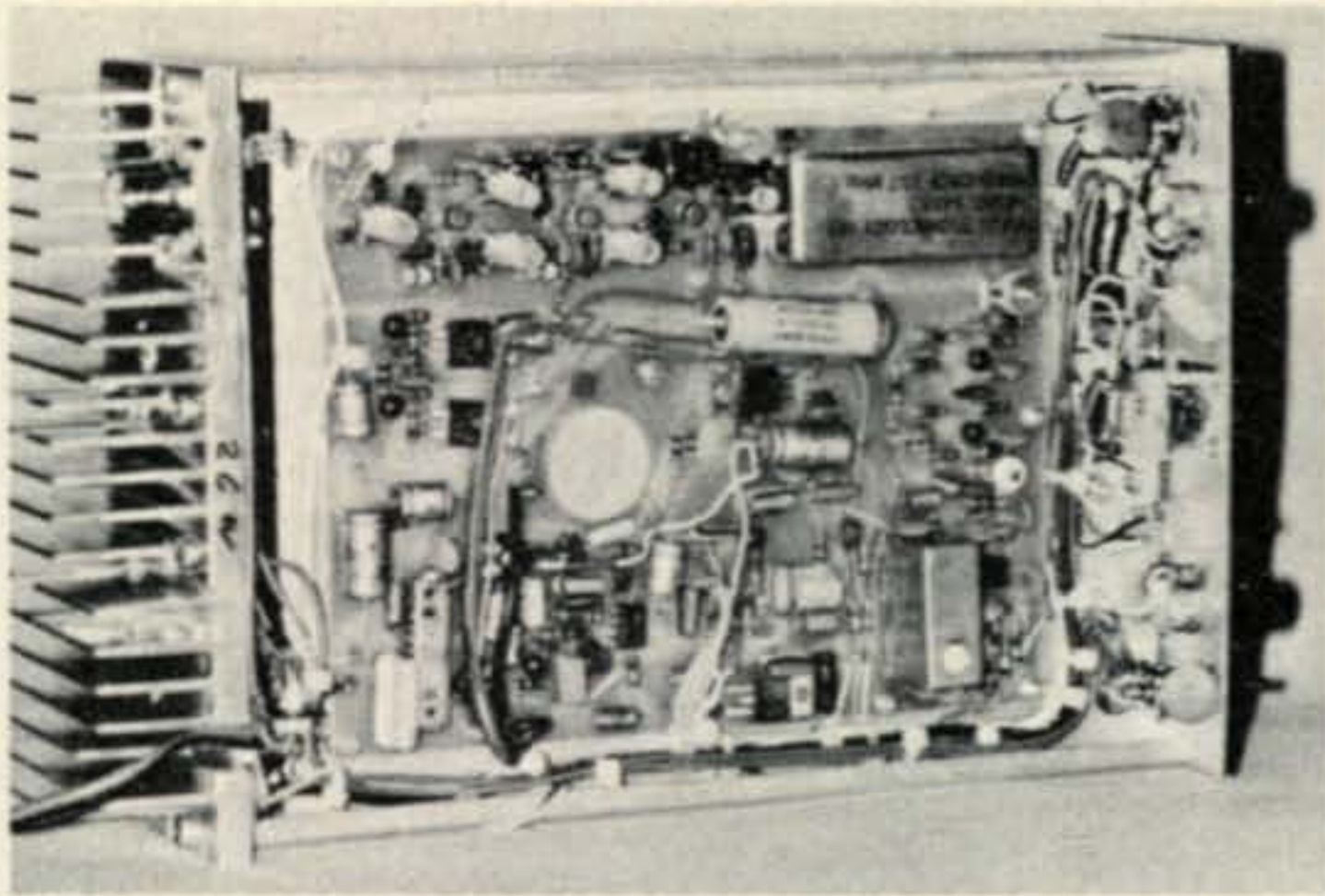
Performance

Initial tests were run on serial number 104 during a period of about five weeks, and due to the nature of the results obtained, this writer made an unexpected visit to the factory and requested that the unit be exchanged for another serial number selected at random from the production line. All major measurements were repeated using identical techniques and the results obtained in the first run were found to be essentially the same for the random-selected serial number 147A.

The EBC-144 JR. is the finest piece of two meter f.m. gear this writer has used to date.

It is the first truly narrow-band receiver that we have seen and it appears to be totally free from transmitter spurious signals. It operates in high-signal levels like no other receiver this writer has ever handled. For example, connected to a "long John" fifteen-element yagi on a 28 foot boom pointed at the WR2ADM repeater only 1.8 miles from our house, with the repeater running about 250 watts ERP, the EBC-144 JR. shows no trace of that repeater when tuned 15 kHz above or below the repeater frequency. As a matter of fact, we were able to work easily through a repeater in Connecticut only 15 kHz off the local machine with no sign of adjacent channel interference. All other transceivers in use failed this test miserably, including a well-known commercial f.m. unit with a narrow filter.

The narrow-band performance of this receiver is so striking that it will introduce problems for some repeater operators. The unit will accept no more than 7 kHz deviation without producing audio distortion, and the less-informed users will complain that the receiver has "lousy audio." In addition, if the output frequency of the repeater being received is more than one kHz off the nominal frequency, distortion at even normal narrow-band deviation will appear. This has been proven here in our local area where we have two re-



Bottom view (left) of the '144 JR. showing the heavy aluminum heat sink which comprises the entire rear panel of the rig. Portions of the extruded fins are milled away to provide mounting space for the output UHF connector and the PA transistors. Top view of the EBC-144 JR. (right) shows some of the extensive shielding used internally.

peaters available on the same frequency. For a time the local machine was about two kHz higher than the nominal and sounded very rough, although another repeater on the same frequency in nearby Connecticut was quite clean.

I would suggest that when users of the EBC-144 JR. think that the audio is lousy, check to see what the other station sounds like on the input frequency of the repeater. You may be pleasantly surprised. It is obvious that quite a few repeaters are neither on frequency nor set for proper deviation.

All measurements were performed with a supply voltage of 13.5 volts. Total power demand was 1.05 amperes in the receive mode and 5.1 amperes in the transmit mode. With this primary voltage, output power into a dummy load measured 20.5 watts plus or minus 2 watts from 143.5 MHz to 148.5 MHz, which would be about a 1 db variation in power over the band. Power output for primary voltages between 10.0 and 18.6 volts varied from about 12 watts to just over 30 watts. The performance of the synthesis and logic circuits did not vary over these voltage extremes.

The equipment was subjected to temperature variations from 20 to 125° fahrenheit, with no noticeable problems. On one occasion, the unit was placed in the home freezer overnight, then removed and plugged in after 9 hours in the freezer. It came up immediately with no observable problems. The consideration here, of course, was to simulate the effects found when one's car sits out in the freezing weather all night without a garage, and the gear remains in the car. Previous experience has shown the very low temperatures to be a problem for some of the semi-synthesized radios on the market. The higher temperatures are not unusual when one lets the rig sit in the car parked all day at Jones' beach on a summer Sunday afternoon. The EBC-144 JR. survived these tests and should prove one of the few

units on the ham market capable of maintaining it's "cool" under such trying environmental circumstances.

One question that has plagued me for years is the case of "duty-cycle." This is of paramount importance to many of us who run a.f.s.k. radioteletype on two meter f.m. In RTTY transmissions can run twenty to thirty minutes in duration, and, frankly, I have been through hell making modifications in all kinds of rice box radios and even commercial f.m. gear to reach a point where a half-hour tape can be sent without watching the transmitter dissolve into a ball of steaming metal and plastic!

I must confess that I have been unable to kill the EBC-144 JR. Without any modifications, the rigs tested here were able to run a.f.s.k. RTTY for up to sixty minutes without anything more than a hot heat sink. No significant drop off of power was observed. This speaks well for the design and construction of the power amplifier.

One of the more outstanding characteristics of the EBC-144 JR. is its ability to exist in an area of multiple high-power repeaters without developing an acute case of Bubonic Intermodulation. I live in a location where there are two high power two meter repeaters within several miles of me and each other, along with some local fellows who run fair power levels on 146.94 MHz. Past experience has shown the majority of equipment used at this location sooner or later falls prey to the evils of IM in the front end due to high signal levels. In three months of careful observation, the EBC-144 JR. has yet to reproduce signals not specifically intended to appear where they appear. In other words, the excellent front end characteristics along with the single-conversion techniques employed make this the only receiver that I have enjoyed here at home that is exempt from the usual problems. A rare bird, indeed!

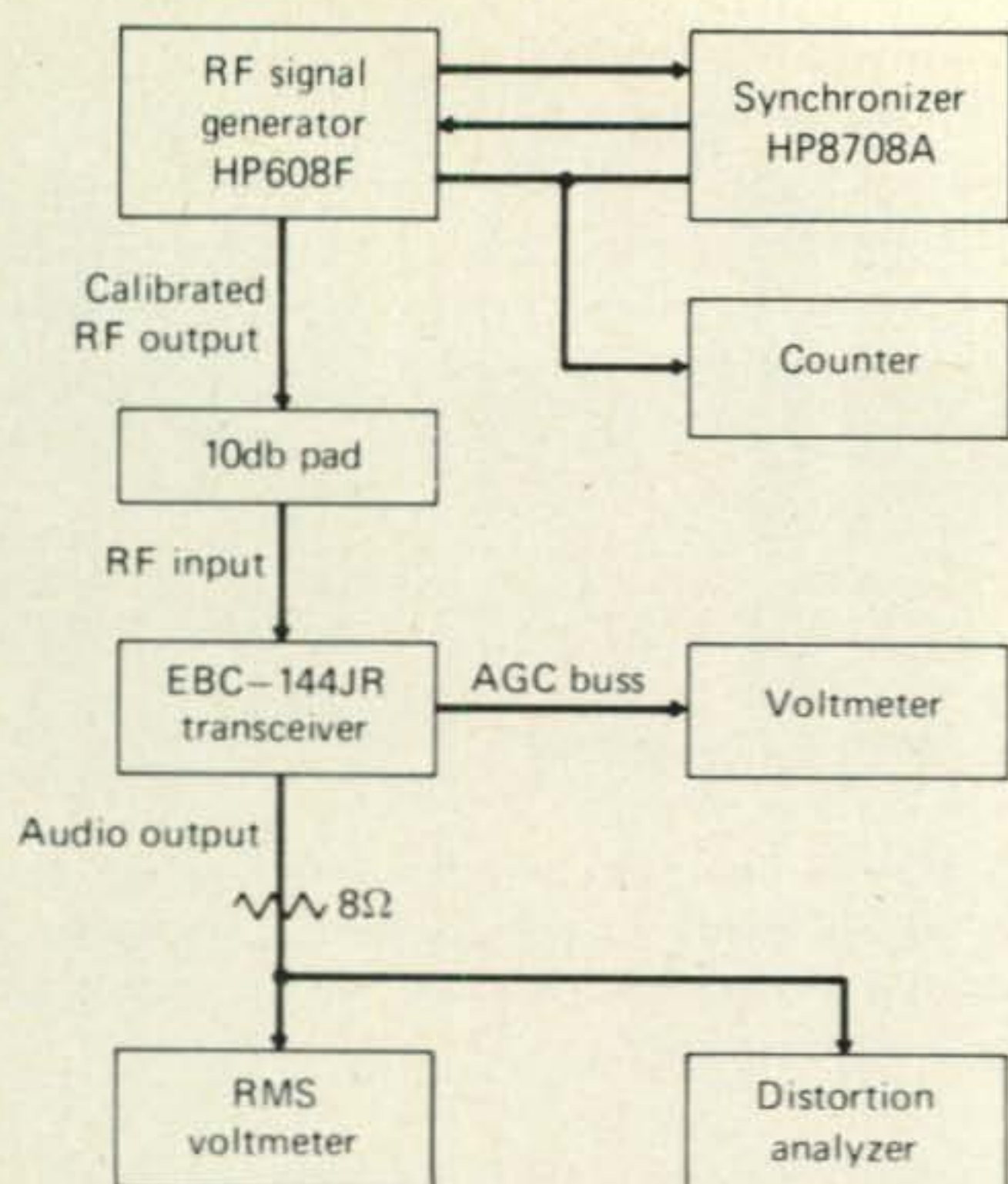


Fig. 2—Test equipment setup used for receiver performance measurements.

The specified receiver stability of the unit is .001%, which at 146.0 MHz, would be on the order of 1460 Hertz. Lab measurements show the receiver to maintain tolerances well within the spec, on the order of 300 Hertz. Transmitter output frequency falls within 250 Hertz of the nominal values over the entire operating range.

Using the classic methods involving noise figure and established bandwidth, it is possible to predict the maximum theoretical sensitivity of a receiver. But one gets into trouble when the receiver begins to demonstrate sensitivity approaching these limits. Signal generator leakage became a problem while testing the EBC-144 JR, and it became necessary to place the transceiver in a screen room and run the r.f., audio and a.g.c. lines outside the screen room. The receiver was evaluated for both the 12 db SINAD rating and the 20 db quieting standards. Although the specs call for $0.35 \mu\text{V}$ for 12 db SINAD and $0.30 \mu\text{V}$ for 20 db quieting, both units tested demonstrated repeatable values of $0.24 \mu\text{V}$ and $0.20 \mu\text{V}$ for 12 db SINAD and 20 db quieting respectively.

Figure 2 shows the test equipment setup for receiver measurements.

The use of at least 6 db of attenuation in the output of the signal generator is in accordance with good engineering practices and is essential to maintain some semblance of accuracy in the calibration of the generator attenuator. The generator-synchronizer combination assures the stability of the signal source to within less than 50 Hertz during the test period. With the DVM on the receiver a.g.c. buss, an a.g.c. curve was run, and the parameters established for 3 and 6 db points used to determine the bandwidth limitations. The r.m.s. voltmeter serves as the

medium for the quieting measurements, with the noise and distortion analyzer functioning for the SINAD tests.

Adjacent channel rejection measured 88 db at 15 kHz. Spurious and image responses were down 70 db.

Figure 3 is the equipment setup for the transmitter performance evaluation. A series of calibrated directional couplers and attenuators serves to reduce signal output levels to values that can be accepted by the spectrum analyzer without risking the generation of internally-produced IM products in the analyzer. Voltages presented to the analyzer were on the order of 20 microwatts, or less. The only spurious signals found in the transmitter output were a pair of symmetrical signals about 15 to 18 kHz out from the carrier, at a level of approximately 14 db below carrier. Second harmonic and other unwanted outputs were better than 70 db down from carrier.

Picking Nits

In analyzing receiver performance, the mixing and synthesis schemes were examined to predict receiver spurious signals. A series of receiver spurs was found, as predicted. The two worst offenders occur at 144.535 MHz, and 146.25 MHz and although these two surplus signals are quite evident when the squelch setting is sensitive, they can be squelched out. Measurements showed the signals to be less than $0.04 \mu\text{V}$ equivalent signal strength, values which any useable incoming signal will easily override.

Another problem awaiting solution is the illumination of the front panel. The thumb-wheel switches do not have internal lighting, but I have seen a prototype of an "eyebrow" type external lighting fixture which can be

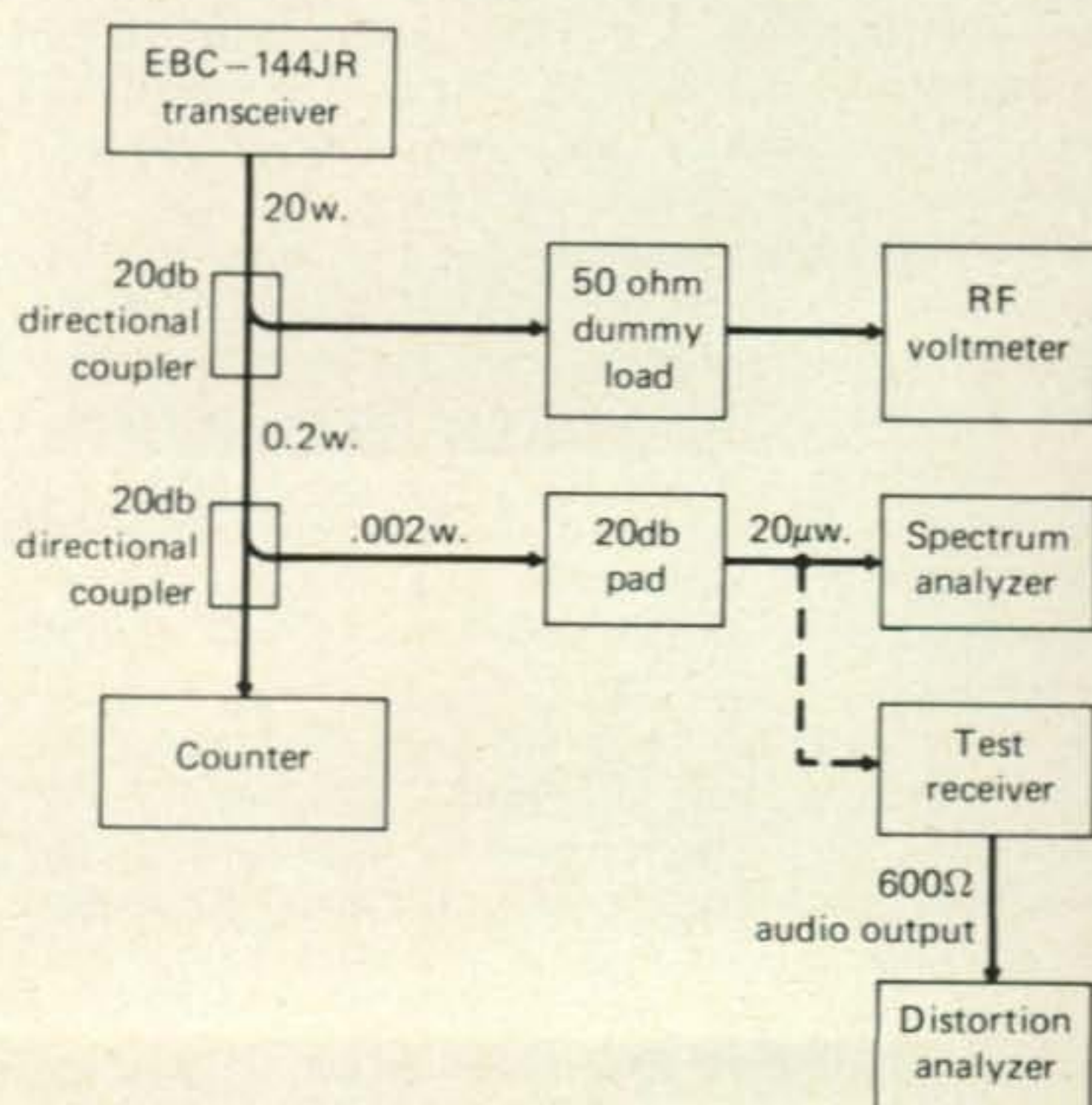


Fig. 3—Test equipment setup for transmitter tests.

added on to the front of the unit. I suggest that EBC speed their efforts in this direction.

Another area that could be improved would be the upper end of the transmitter audio pass-band. The top end rolls off too fast, with 3000 Hertz being down about 13 db reference to 1000 Hz. While this may not be meaningful in the average voice operator's situation, those of us who will use the rig for a.f.s.k. RTTY will find some problems when working stations with less-than-optimum receivers and demodulators, or through direct, non-regenerative repeaters which in themselves have high-end roll off problems. The pre-emphasis network needs a bit of reworking, a simple matter.

While we pick some nits, EBC could also consider swapping the volume and squelch controls. The presence of the mike jack and plug on the front panel is no problem, but the plug sticks out annoyingly close to the volume control. Since the squelch control gets far less use than the volume control it would seem logical to interchange the position of the two.

Now for the metering. Here, I feel that EBC dropped the ball. The receiver signal strength indication is taken from an output on the detector chip. But between the meter which has no calibration, and the fact that the needle never goes above half scale, those of us who want to orient some kind of a beam with this meter have a bit of a chore on our hands. This meter circuit and the display needs some rework. The same thing for the transmitter output reading. It would be far more interesting to have some kind of a meaningful indication available. Further, although the meter is illuminated after a fashion, it is totally unreadable in the dark. This too needs work!

Operation

Operation of the EBC-144 JR. is unique. Two sets of thumbwheels marked "A" and "B" can be used interchangeably. A three-position toggle switch selects either the "A" or "B" thumbwheels or the Priority mode. Normal or most conventional operation would set the "A" thumbwheel to the output frequency of the repeater being worked, with the mode switch in the "Auto" position. The logic will offset the transmit frequency 600 kHz downward when the first digit in the thumbwheel is "6," and upward when the first digit is "7." Below 146 MHz the offset feature is defeated and the transceiver is automatically in a simplex mode. In the "Reverse" position, the offset is reversed. This mode would be needed when working a repeater whose output frequency is 147.00 MHz. In the "Simplex" position, the unit performs in exactly that manner with reception and transmission on whatever frequency is cranked into the selected thumbwheels. The fourth mode on the mode switch is the "Split" mode, and that will be used for working repeaters with other than



Portent of things to come? The EBC-144 JR. is factory sealed to prevent access to the interior. The whole idea of discouraging the buyer from opening his expensive new toy is alien to amateur radio, although EBC's desire to keep "Harry-the Ham's" handy-dandy alignment tool out of the works is understandable.

600 kHz spacing. In this position, the "A" thumbwheels will set the receiver frequency and the "B" thumbwheels will set the transmit frequency. Thus, one can set up to work any pair of repeater input-output arrangements that any repeater operator can invent. Most flexible!

For use of the Priority feature, the "A" thumbwheels will set up your normal repeater or simplex mode, and you dial up the "B" thumbwheels for the frequency that you wish to monitor on a priority basis. When the toggle switch is set to "Priority," the receiver will take a look at the "B" frequency for a period of about 100 milliseconds every two and one half seconds, and if any signal appears on the "B" channel, the logic will lock the receiver to that channel for the length of time that it is occupied, returning to the "A" channel when the "B" channel signal goes off the air. If the transmit switch is pressed when the receiver has locked to the selected priority channel, then the transmitter will transmit on the priority channel. Very handy feature that will find innumerable applications among users who work several repeaters.

Another handy feature available with the dual-thumbwheel programming is the ability to set up the "B" thumbwheels on the input to the repeater you are working on the "A" thumbwheels. If you happen to work a repeater which has a cranky time-out system, and some of your friends seem to frequently time out the machine, you simply flip the toggle switch over to the preset input and you will be able to copy your "timed-out" buddy if he is within direct contact range. Saves the need for repeats.

One caution before ending this appraisal. Due to the fact that the EBC-144 JR. is designed to work the CAP and MARS frequencies just outside the amateur band limits, some care must be exercised in the early days with the unit. It is possible to inadvertently

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tubes which had manufacturer's filament ratings in excess of the maximum wattages specified, then the FCC's job would be made infinitely simpler in its policing efforts. It would be a simple black or white infringement of the rules.

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operate outside the band if you are not careful. Double-check your switch settings when you first begin to operate the rig! After a few days, this will become second nature.

Even with a few short-comings, this radio is, in the opinion of this writer, the most important single piece of v.h.f. equipment to enter the amateur radio scene in many years. It will be the forerunner of an entire new class of sophisticated radios which will reflect the constantly advancing state of the art. The EBC-144 JR. will furnish a fine target for the other manufacturers to shoot at. I wish them all the best luck. The only question that I have left is this . . . what will EBC do for an encore?

—W2JUP

QRM [from page 26]

3 el. beam certainly helped me a lot!! See you all next year. Please tell me who has the top Novice record all-time and how many points . . . *WN2SJK*. 15 was a very dependable band to Pacific. Wish I had not had to work all weekend, think I could have run up a good score. Conditions better for c.w. test than fone test . . . *WA4OSM*. 15 put on a great show for the contest Saturday afternoon . . . *WA2LJM*. Bad weekend for me, signals were great but had to go to a funeral out of town on Saturday which shot that day completely and had company part of Sunday . . . *K0ARS*. All those *KH6*'s sure sounded like *KS6*'s! . . . *WB0LTD*. No activity from zone 34; missed 4 here — but know *JT1KAA*, *VS6DO* and *9M2CX*—zones 23, 24 and 28 respectively were on okay . . . *W4AAV*. Move it back to Thanksgiving! On second thought, don't! . . . *W9KNI*. Only 7½ hours of operation before linear transformer cratered . . . *W5WZQ*. Good conditions to JA Saturday morning . . . *WA4APG*. Not much time to operate. Maybe you can use log anyway for check . . . *W8CNL*. Good scores could be gotten on 80 if there was more activity from the rest of the world in general because propagation was good. How about an 80 m. contest like ARRL's 10 m. contest? . . . *W7KAR*. A steady S7 power line noise sure hurt with the weak ones . . . *VE3DXV/W6*. Total it for club total only . . . *W5LUJ*. First night great—had visions of some kind of record in the making (Hi). Second night—local thunderstorms all night long (sob!!) . . . *W5RTQ*. No openings to Europe or Africa this year. Very poor conditions, but lots of fun. Also note a big decrease in operating skills. DX unable to handle pileups . . . *W7JLU*. Disappointed in lack of activity—especially Saturday night . . . *K2TXC*. A few hours well spent . . . *K6NA*. Must study and get extra—really difficult above 3.25 on 80m . . . *WB8EUN*. A pleasure to get into this test after so many years. Was absent due to Thanksgiving previously. How about alternating c.w. first, phone second, etc., each year? . . . *W9DY*. Biggest Thrill: Working three new countries—*ST2AY*, *OD5IQ* and *DJ8QT/CT3* to bring my total to 122 countries on 160! The exceptional 160 meter band opening to EU/AF on Sunday morning allowing QSO's in rapid succession, like having a "pipe-line" from here to there!! Fine operators and nice guys on for the test. 160 is "still a gentleman's band!!" Thanks for running such a nice contest . . . *W1BB*. Will be quite surprised if the *FY7* proves legit . . . *K5JVF*. Nuts . . . *WA7OAU*. Hope I never have to turn another beam by hand again . . . *W5KFL*. Won Worth Township (both modes now that *W3GPE* has moved 30 miles away . . . *W3FRY*. Sure is frustrating hearing them so loud on 160 and not be able to work them . . . *W3WJD*.

Operators [from page 32]

OK1KRQ: OK1IAM, OK1IVJ, OK1IAV. **OK3KGQ:** OK3-2351, OK3ZAD. **OK3KTY:** OK3ZFB, OK3ZGA. **OK1KCD:** OK1-AWF, PO-8523. **OK3KAG:** OK3CIR, OK3YBD, OK3ZFM, OK3ZAF. **OK1KCF:** OK1KZ, OK1XC. **OK2KOO:** OK2BIP, OK3TBC. **OK3KJX:** OK3EQ, OL8CDQ. **OK1KTL:** OK1OA, OK1AWC, OK1AQT, OK1FCA, OK1AZO, OK1SB, OK1-ATW, OK1TY, OK1APS. **OK2KYK:** OK2PBM, OK2BGH. **OK3KPN:** OK3CJN, OK3ZMJ, OL0CBX. **OK1OFX:** OK1MX, Et. Al. **ON4UB:** ON5MF, ON6VL, ON6MH, ON6QR. **ON5-KH & ON6HE:** ON5UQ, ON5CY, ON6KD, ON5JE, ON6MD. **OY6FRA:** OY2H, OY2J, OY3B, OY3H, OY5NS, OY7YD, OY7M. **LZ2KDP:** LZ1GX, LZ1-F-3Z, LZ-2-H-5Z, LZ1-A-513, LZ1-A-584, Palm Stan. **LZ1KBU:** Hazlov, Sekezly. **LZ1KCP:** Vatev, Slavchev. **LZ2KDI:** Atanas, Tribondy, Muhsin, Jordanov. **LZ2KEF:** Wasilev, Penchev, Marinov. **LZ2KWD:** Georgiev, Georgiev. **LZ2KHM:** Pesvnov, Petrov, Ivanov. **LZ2KAD:** Nerov, Mihailov, Runtchev, Stefanoff. **PA9AEH:** & **PA0PN, PA0ABM, PA0INA.** **PI1PT:** Van Kessel, Kokee. **PY1EMM:** PY1TC, PY2GRO, PY1ZBJ. **SK2DR:** SM2EKM, SM2CEW. **SK2AU:** SM2DQS, SM2BJE. **SK6BA:** SM6CKU, SM6DHU, SM6EVE, SM6FYJ. **SM5AOE & SM6BJI,** SM5-CZT. **SM0BDS:** SM0GBB, SM0PX. **SP1KBK:** SP1AEN, Zakrzewski. **SP2KDT:** SP2GUB, SP2HMY. **SP2ZHB:** SP2-GRT, SP2HJL. **SP2BNF,** Pasikowski. **SP5KMB:** SP5FTH, SP5GEV. **SP9PBN:** SP9HZV, SP9GFY, SP9GTR. **SQ4PBI:** SQ4FAL, SQ4FAO, SQ4ELO, **SQ3PTE:** SQ3FLR, SO3HRN. **SQ5PSL:** SP8GNF, SQ7DQN/5, SP3HVB, SP8GAZ. **SQ9-KRT:** SP9HMF, SP9FKQ, SP9ZW. **SQ9KGC:** SP9CUX Et. Al. **UK4HAW & UA4IU,** UA4HAL, UA4HBR. **UK9FER:** UA9-FAJ, UV9FN, UA9FDW, UA9140005. **VK5NO & Son.** **WA1-NRV.** **WA1UBC & WA1JSD,** WA1LNH. **W2YD & W2BHM,** W2HZY, WA2SRQ. **WB2SQN & K2KUR.** **W2REH & W2-HHB.** **W3BWZ & W3NL,** WA3NGS, K4CFB. **K4GSU & K4FU,** K4KSC, W8FAW, WA8YVR. **K4VX & WB4SGV.** **K4UT & W4LCP,** K4THA. **W4QCW & WA4QOC,** WA8-ZDT. **K4YFQ & WA4BTC** W9JK. **W4OZF & WA4BTR.** **WA4-ZHB:** WA4FCT, WB4HYN, W9QVY, W0PBI. **WB4EMF & WB4KSS.** **K4FW & W9NN.** **W4MII & WB2QHB,** WA6PAQ, K5WTA. **WB4HQE & WB4FDT.** **WA5LES & W5ARJ** W5VQ, K5PFL, WA5WCT. **WA5RXT & WB5JJE.** **W6KG & W6DOD.** **W1ARR/6 & WA6GMR.** **K6HIH & K6AUC.** **W7NQ:** W7CFJ, W7JST, WA7VEN. **W7DAZ & WB7UOV,** WN7YPF. **W8ROF & W8KPL,** WA8EDC, WA8LYF. **W8KIT & WB2FGA.** **W8UM:** WA8GGN, WA8PVY, WA8YTL. **W9ZTD & W9VNE,** K9OTB, WB9IVC, WB9BUV. **YO3KBC:** YO3YZ, YO3JE. **YO4K CZ:** YO4HW, YO4SI, YO4ASP, YO4AVR. **YO8KAN:** YO8ME, YO8MI. **YO8KGA:** YO8DD, YO8FZ. **YO6KEW:** YO6ADM, YO6MY. **YU1BCD:** YU1NQW, YU1NZV, YU1ODO, YU1PCF, YU1QBC. **YU2ACF:** Petar, YU1NVT, YU2RPT. **YU2BTU:** YU2RMT Et. Al. **YU2BOP:** YU2ZP Et. Al. **YU2CBM:** Koljatic, Skoko, Grubisic. **YU2CBV:** YU2RKE, YU2RTG. **Zeljko,** YU2RPY. **ZF1AL & ZF1CN.** **4M5ANT & YV5AAS,** YV5BNR, YV5BZT. **4U1ITU:** HB9AXK, HB9AZD. **4Z4IX & 4Z4DZ,** 4X4WN.

Multi-Operator, Multi-Transmitter

JA3YKC: JA2VUP, JA3ODC, JA3QOG, JA3REU, JA3UHM, JH3BNH, JH3FZB, JH3GLP, JH3HBF, JH3LIJ, JH3NYM, JH3PLE, JR3WBE, JE3BYW, JE3JBI, JA4LVF, JA5GLY. **JA2YEF:** JA2SAP, JA2SWH, JA2TAP, JA2TCA, JA2VHO, JH2BFT, JH2IRH, JH2NTZ, JH2XQY, JR2ADN, JA0TJT. **JA9YBA:** JH1GUO, JH2SGU, JA2NXX, JR2AKB, JA3VEN, JA9GLL, JA9GGH, JA9DZS. **JA1YSI:** JH1BIH, JH1CJU, JA1UGJ. **OH3MG & OH2DT,** OH3IR, OH3RJ, OH3SA, OH3WZ, OH3XZ, OH3YI. **PJ9JT:** DJ3KR, K4GKD, PJ2ARI, PJ2VD, W1BIH, W1GNC, W1TX, W3LPL, WA1STN, WA1-STO. **SK5AJ:** SM5AD, SM5AXP, SM5AYY, SM5BNZ, SM5-CAK, SM5CBN, SM5CNQ, SM5DUS, SM5DYQ. **SQ3KEY:** SP3CTQ, SP3FUO. **SQ6PAX:** SQ6FJG, SP6HEK, SP6EEK, SP6FRA, SP6GIY, SP6DVP. **W2PV & K1OME,** K1ZND, WA1-ABV, WA1ABW, WA1JYY, WA2CLQ, WA2LQZ, WB2OEU, WA2SPL. **K2CW & W2BCU,** W2LSX, K2BPP, K2JOA, K2JQR, WA2DSA, WA2GAV, WB2APO, WB2BYW, WB2FTQ, WA3BNF, WN2VZZ, WN2VZY, T. Edens, R. Hazen. **W3AU & W3ZKH,** K3EST, WA3AMH, WA3HRV, WA3IAQ, WB4-ODN. **W3WJD & W3DQG,** WA3JLT, WA3LRO, W6MWJ. **W3GPE & K3OIO,** K3WJV, WA3FFR, WA3GUL. **W3GM & W3FM,** W3JSX, W3KFK, K3ZOL, WA3JYB. **W3FRY & K3H-TZ,** K3DZB, WA3LNM, WA3NQX, WA3WIM. **WA3ATX & WA3COJ,** WA3GJZ, WA3SZI. **W3TV & W3AOH.** **W3VW.** **W3BYX & WA3KRD.** **WA5JMK & WA5UCT.** **W5KFL & WA5OCN,** WA5ZWC, WB5DDI. **WA6EPQ & WA6IPY.** **W7-SFA & W7APN,** W7ENM, W7EXM, K7JCA, K7VPF, WA7OTT, VE7ZZ. **YV5RT:** YV4TI, YV5AW, YV5CET, YV4ID, YV4CI, YV4NQ, YV1MV, YV4AE, YV4AC, YV4AOO, YV4ATW, YV4BE, YV4AY. **6Y5BF & K4CEF,** K4SHB, K4LDR, W4-BRB, WB4TAF, WB4FLW, W9NFC, K4VC, WB4KZU, W4MV.