THE WATKINS-JOHNSON HF-1000 DIGITAL RECEIVER:
First Impressions

David Clark and James Goodwin

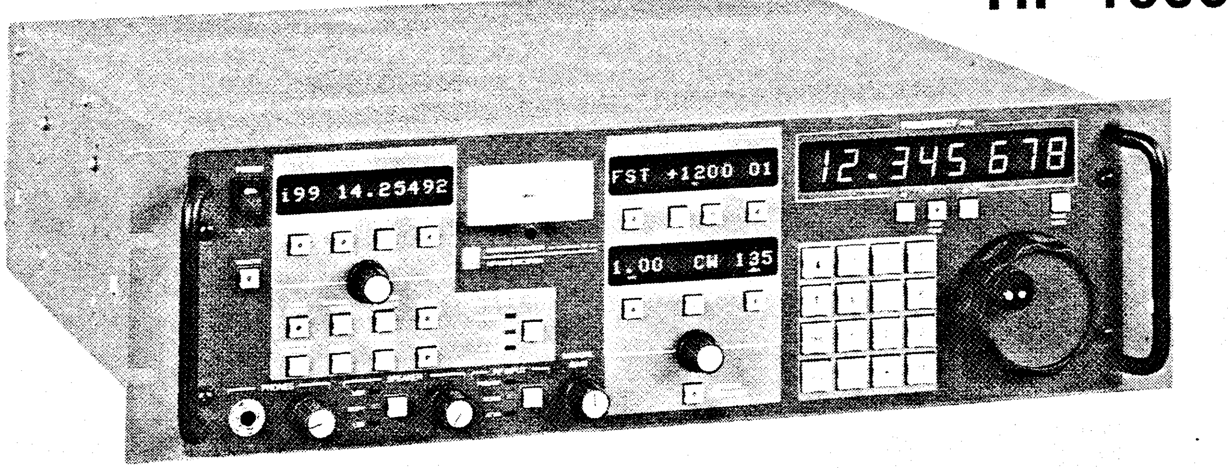

Figure 1. MODEL HF-1000 GENERAL COVERAGE RECEIVER

INTRODUCTION

The Watkins-Johnson HF-1000 has created a great deal of interest among DXers and SWLs since it was introduced in September of 1993. It has almost everything anyone could want, including some features no hobbyist could have even dreamed of just a short time ago. The capabilities of its digital signal processing circuitry give us an early view of what is coming in the years ahead, but at a price approaching $4,000.

Late last winter, David Clark obtained an HF-1000 on a brief loan from Norham Radio, a leading Toronto-area dealer which is also the sole Canadian retailer of the receiver. Although Proceedings normally waits at least a year after the first reviews of an important new product are out to publish its "definitive user's review", this was too good an opportunity to let pass for some comment on an initial test run.

What follows is not intended as an exhaustive review. We give an outline of the HF-1000's major features and state our findings from a rather abbreviated test period. We have added our individual remarks where appropriate, in italics and they are indicated by (DC) and (JG).

After our receiver try-out, Watkins-Johnson introduced a firmware upgrade providing synchronous AM detection and programmable AGC. Included is some Company-supplied information on these features and on future plans we learned in June, 1994 discussion with an engineering representative.

In order to provide a broader perspective, we have also incorporated other user comments posted in recent months on computer bulletin boards. The authors wish to acknowledge the co-operation of Ben Krepp in forwarding a number of the postings to us.

We also acknowledge the cooperation of Bill Bowers and John Bryant who made available some test results which relate the digital RF interference generated by the HF-1000 in comparison with several other currently popular, high-performance communications receivers.

RECEIVER AND CIRCUITRY

Anyone who has used only the consumer-type communication receivers of the last 20 years may find the HF-1000's size initially unsettling. Because the HF-1000 has been derived from the WJ-8711, a receiver designed for military/commercial use, some of its dimensions were designed to meet rack-mount requirements. The receiver is 19 in. wide, 5.25 in. high and 20 in. deep. Modern miniaturization makes for a rather empty box weighing only 15 lbs.

The HF-1000 consists of an analog tuner, IF digitizer, digital signal processing and analog reconstruction circuitry, and front panel control logic. These operating components are contained on three printed circuit assemblies which, with the power supply, comprise the complete receiver. At first glance it appears deceptively simple. In reality it is an extremely complex unit, incorporating extensive state-of-the-art DSP processing capabilities.

The receiver is tunable in 1-hertz increments over the range of 5 kHz to 30 MHz. Detection modes are synchronous AM (see further notes following), FM, CW, USB, LSB and ISB.

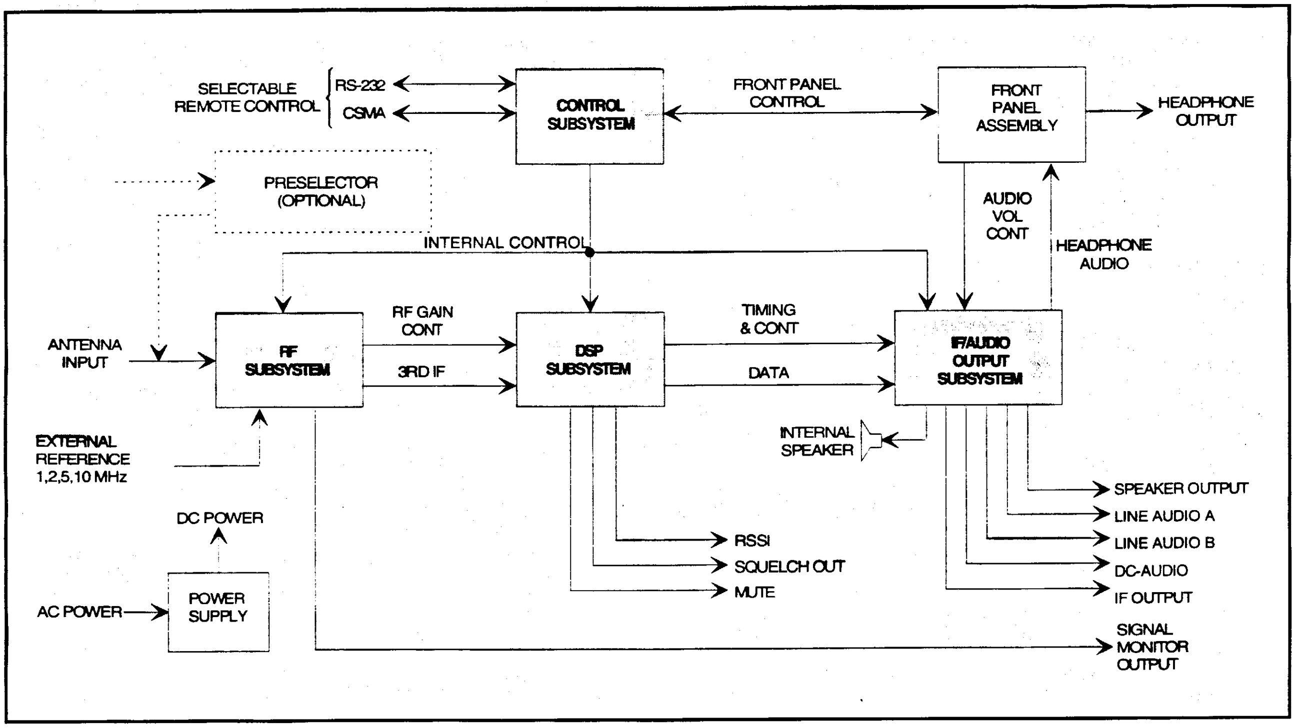

FIGURE 2. HF-1000 SIMPLIFIED FUNCTIONAL BLOCK DIAGRAM

Figure 2, taken from the manufacturer's Technical Data Sheet, shows a simplified functional block diagram of the HF-1000. The received RF signal is mixed with that of a first local oscillator, which tunes from 40.455 MHz to 70.455 MHz in coarse 1-kHz steps, to produce a first IF of 40.455 MHz. A filter limits the signal's bandwidth to 8 kHz. Further successive mixings with a 40-MHz oscillator and a 430-kHz oscillator produce 2[nd] and 3[rd] IF's of 455 kHz and 25 kHz respectively.

The 25 kHz signal is digitized to 16-bits resolution at a sampling rate of 100 kHz. The digitized signal is applied to a programmable DSP chip that performs the functions of noise blanking, fine tuning to 1-Hz resolution, IF filtering, passband tuning, tunable IF notch filtering, manual and automatic gain control, signal strength and squelch functions, signal demodulation and BFO, generation of a multiplexed digital data stream containing one or two demodulated audio channels, and a post-filtered IF signal.

The receiver's IF/Audio Output Subsystem then performs the analog reconstruction of the IF and audio signals provided by the DSP Subsystem in digital form. The reconstructed analog IF signal is upconverted to 455 kHz and made available at the receiver's rear. The reconstructed audio is directed to various audio outputs, including an 8-ohm 4-inch internal speaker under the receiver's top cover, the 600 ohm front-panel phones jack and the several outputs available from the rear panel.

MANUAL

The Manual which came with our test receiver is titled "Intermediate Level Maintenance Manual for the HF-1000 Digital HF Receiver". It is clearly written and fully explains the receiver's operation. With almost 200 pages of text and illustrations, it has chapters on general description, installation, local operation, remote operation, circuit description, maintenance, replacement parts (referenced by manufacturer) and schematics.

Every receiver coming off the assembly line is subject to an extensive burn-in and specifications check before it is delivered. A seperate bench test report is provided with each receiver too.

FRONT PANEL DISPLAYS AND CONTROLS

The size of the front panel has enabled Watkins-Johnson to provide numerous uncrowded and easy to use controls. Mostare single purpose, the principal exception being the Auxiliary Parameter Edit control knob whose functions are outlined below. The available space permits the luxury of four LED displays although there is no clock.

The front panel layout includes three shaded areas which group particular sets of keys which are associated with specific functional operations. The shaded area on the left side includes all keys and the display associated with the memory and scan functions. The shaded area in the center of the front panel contains the keys, displays and control knob associated with receiver auxiliary parameters such as detection mode, IF filter selection, tunable IF notch, Noise Blanker, Passband Tuning, and so on. Finally, the shaded area right-of-centre highlights the 16-key keypad.

The over-all arrangement is logical and with the very helpful Manual at hand, no new owner will need much time in to become a capable operator. The manual contains a large fold-out illustration of the front panel controls, LED indicators and displays, cross-referenced to the appropriate sections of the text. Figure 3 on the following page (taken from the Technical Data Sheet) highlights the ergonomics and some of the features of the front panel organization.

FREQUENCY DISPLAY AND TUNING

The tuned frequency display is a highly visible 8-character LED display, reading in megahertz. The display contains two digits, a decimal point, and six more digits, in the format xx.xxx xxx.

There are two tuning systems, the common decade method and Step Tune. Either the tuning knob or two up and down arrow keys may be used.

With decade tuning, the tuning-rate increment can be single hertz, 10 Hz or 10x multiples thereof, i.e. 100 Hz, 1 kHz, 10 kHz etc., all the way up to tens of megahertz. The increment is set by using the right and left arrow keys below the frequency display to move a cursor to the digit of choice. The position of the cursor is indicated by the digit which is constantly changing in intensity, a mild blinking that is not irritating.

The tuning knob is 2 ½" in diameter, has a fixed tuning dimple and is apparently unweighted.

The light-weight knob mechanism caused one of the few criticisms I had about the test receiver. The very small additional weight of the dimple seemed to be enough to upset the knob's balance so that when the dimple was in the 9-o'clock position, the slightest touch to the knob would set it in motion for a quarter turn to put the dimple down at 6-o'clock. (JG)

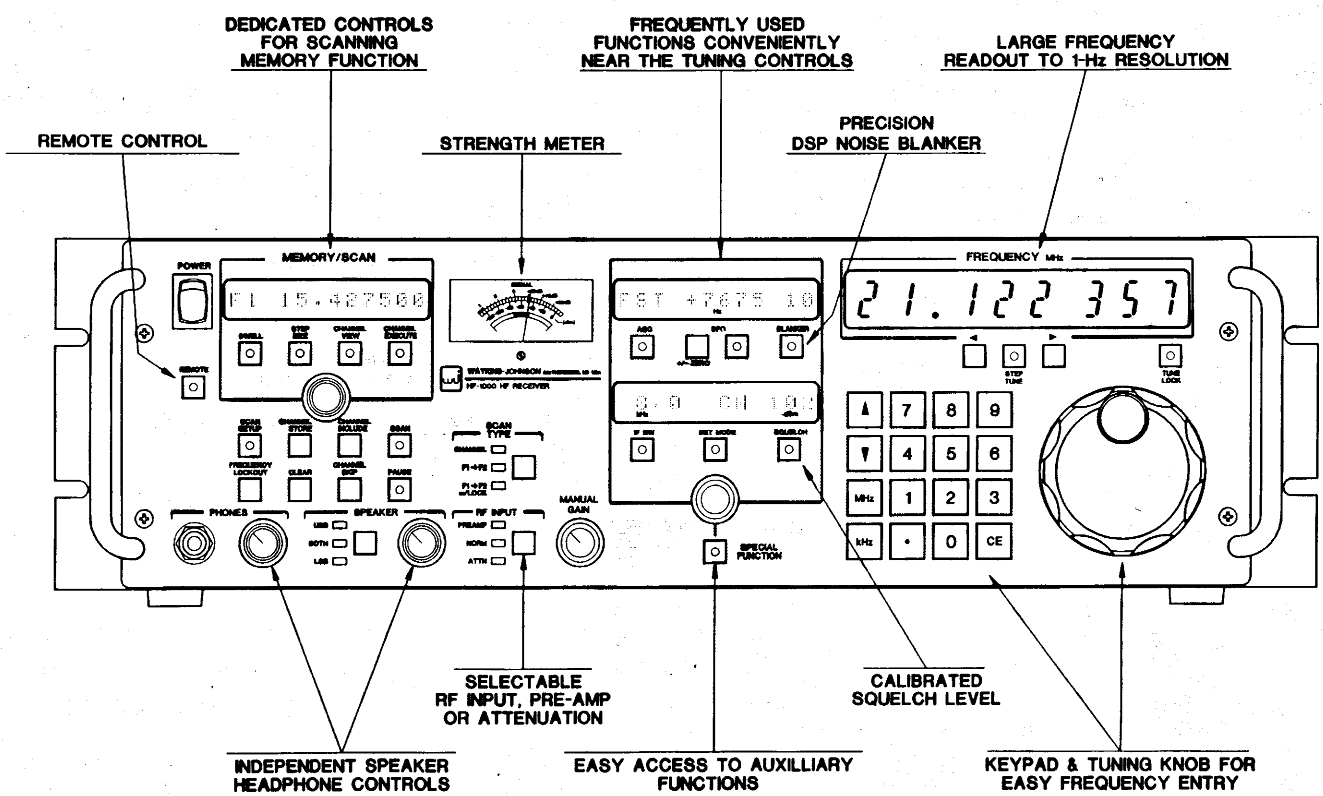

FIGURE 3. HF-1000 FRONT PANEL LAYOUT AND FEATURES

With decade tuning in effect, each press of either the up or the down arrow key increases or decreases the tuned frequency by one increment only. The tuning knob is the more efficient method of the two in most circumstances.

As an alternative to normal decade tuning, the Step Tune key may be activated. The step-size frequency increment currently in effect for frequency scanning in the Memory/Scan section then becomes the default increment for tuning - a change which is still made either by the tuning knob or by the up and down keys. This increment may be anything from 1 hertz to 25 kHz.

A Tune Lock key and LED can be activated to disable the tuning knob and the up and down arrow keys.

KEYPAD

The keypad serves for tuned frequency entry, either in kilohertz or megahertz, and for numerical entries for the various receiver parameters such as BFO etc. Included in the keypad are the MHz and kHz keys which serve as frequency-entry terminators. A CE or clear entry key cancels any partially made and unwanted entry.

We found the large, convex-shaped keys require a relatively soft-touch, making for convenient and error-free fingertip usage. On our test receiver, one of the numeric keys had a tendancy to stick when depressed and this sometimes necessitated repetitive re-entry of the intended frequency. This apparent mechanical fault causes us concern about the long term reliability of the keypad, since we have knowledge of another purchaser's situation where the keypad was also faulty. Hopefully these difficulties have been resolved in later production runs.(DC)

AUXILIARY PARAMETER SECTION

This section, at the center of the front panel, has two 12-character alphanumeric displays. The upper display normally shows the gain control mode, the BFO frequency and the noise blanking level. The lower display normally shows the IF bandwidth, the detection mode and the squelch level.

Below each displayed parameter (or function) is a combination key and LED light which when activated permits a change in the parameters' setting. While each of the keys may be repeatedly pressed to cycle through the respective parameters' setting choices, the all-purpose Auxiliary Parameter Edit knob is a more efficient method. For many of the section's parameters, this knob can be used to display and put into effect one of a parameter's settings.

The Special Function key is used to select Passband Tuning mode, IF Bandwidth Select mode, and a number of other functions which are infrequently used.

SELECTIVITY AND THE DSP FILTERS

One of the most talked-about features of the HF-1000 is its array of 58 user-selectable IF bandwidths with their excellent skirt selectivities and shape factors. The DSP circuitry has produced a capability that could not have been obtained with older, conventional techniques.

For the bandwidth specifications, Watkins-Johnson uses the width at -3 dB rather than -6 dB. The 58 bandwidths range from 56 Hz to 8 kHz at -3 dB, while the -3/60 dB shape factors vary from 1.45 to 1.20, depending on the bandwidth selected. The shape factors would be even more impressive if stated in the more commonly-known -6/60 dB ratio. In the SSB mode, only the widths from 900 to 3200 Hz can be used with the current software.

The user is able to select for quick access only those bandwidths ordinarily used. With the Special Function key, widths can be quickly added to or taken out of this up-front group. It is a simple matter at any time to activate the IF bandwidth key and with a twist of the Auxiliary Parameter Edit knob, to run through the up-front bandwidths and hear their effect on a signal.

I made a number of listening comparisons with the HF-1000 and my Racal RA-6790/GM. The Racal has only a limited number of crystal-lattice filters, and most have 60/3 dB shape factors of 2. It does have a 3.24 kHz filter with a factor of 1.33.I put both this and the similar DSP filter in the HF-1000 up against the worst adjacent-channel interference situations I could find, using both AM and ECSS modes. Lab tests might dictate otherwise, but I couldn't distinguish one receiver from the other. They both seemed to have the same relative successes and failures.

The HF-1000's narrowest filters are an improvement for the CW DX'er. The single-crystal Lamb filters in the old tube receivers could provide a nose selectivity of less than 50 Hz, but the skirts were several kilohertz wide. The narrow CW filters of modern receivers have much improved skirt selectivity, but their nose widths of possibly 100's of hertz don't permit the best signal-to-noise ratio for weak signals. This has often dictated the use of audio filters. The narrowest DSP filters either equal or improve upon the best features of past methods, although they may not give the signal boost that the Q that some Lamb filters provided.

While the range of DSP filters certainly offers the broadcast DX'er far more flexibility in dealing with "tight signal" interference suppression, they are tailor-made for the RTTY user too. No other receiver has had enough filter choices to deal well with the variety of RTTY bandwidths. The multiplicity of selectable DSP filters is a big step toward obtaining better signal-to-noise ratios for all manner of RTTY transmissions.(JG)

Bill Bowers tell us that he finds the 75 Hz position absolutely superb for DXing longwave beacons. For general SWBC purposes, however, Bill considers the Japan Radio NRD-535D to be his number one receiver and superior to the Drake R8 because of the flexibility afforded by the Variable Bandwidth Control.

I do little utility DXing (CW and RTTY modes) but side by side tests of the HF-1000 with a Drake R8 fed concurrently by the same antenna through a multicoupler rendered similar results, for approximately equal bandwidths on the Tropical Bands. (DC)

The following comment posted on Internet does, however, constitute another user's assessment of an apparent difference in performance between DSP and analog filters:

> *It seems to me in listening and comparing the HF-1000's weak signal performance that the difference has something to do with the difference between analog and digital filters. I can use a digital filter whose bandwidth is much smaller than an analog filter and hear about the same audio response. For example, the HF-1000's 1.8 kHz filter sounds very much like the NRD's (525 with Eska) 2.4 kHz filter.And yet filter curves I have generated on the NRD 2.4 and HF-1000 2.4 filters really do have that bandwidth. I think the difference lies in the phase characteristics of the two filters. It is possible to design a digital filter with linear phase, but the NRD analog filters are not linear phase. The phase rotation at the filter edge with an analog filter must allow more noise to get through with less coherent signal.* - John Reed, KA5QEP

SENSITIVITY, THE PREAMP AND ATTENUATOR

We found the receiver's sensitivity to be quite good, though unexceptional. Man-made and natural noise, particularly at lower frequencies, will be the limiting factors for most weak-signal reception.

The front panel RF Input key selects either normal reception, 10 dB signal preamplification or 15 dB signal attenuation. Preamplification is disabled when the tuned frequency is 500 kHz or less. On a 10 dB S+N/N basis, the HF-1000 is said to have at least the following sensitivities over the 500 kHz to 30 MHz range:

MODULATION	I.F. BANDWIDTH	STATED SENSITIVITY WITHOUT PREAMP	STATED SENSITIVITY WITH PREAMP
AM (50% mod., 400 kHz)	6.0 kHz	1.58 microvolt	not stated
USB/LSB/ISB	3.2 kHz	0.56 microvolt	not stated

My URM-25F signal generator is not a lab instrument, but it is fairly well calibrated. A number of current receivers I measured came out with figures well in line with their advertised sensitivities. I found the test HF-1000 did somewhat better than what is claimed. The following are the average measurements at many frequencies over the .5 to 30 MHz range. Variations were generally +/- 10 percent. (JG)

MODULATION	I.F. BANDWIDTH	MEASURED SENS. WITHOUT PREAMP	MEASURED SENS. WITH PREAMP
AM (50% mod., 400 kHz)	6.0 kHz	1.0 microvolt	.65 microvolt
AM (30% mod., 400 kHz)	4.0 kHz	1.3 microvolt	.85 microvolt
SSB	3.2 kHz	0.3 microvolt	.20 microvolt

Watkins-Johnson says the preamplifier gives a 10 dB signal gain and the attenuator a 15 dB reduction. I found this to be true, although my 10 dB gain figure was simple signal gain and did not take account of the increase in noise. With this taken into account, the net signal improvement provided by the preamp varied from 3 to 4 dB. Using a Grove TUN4 preamp/tuner instead of the receiver's preamp resulted in respective averages of .50 and .65 microvolt in place of the preceding figures of .65 and .85 microvolt.

As for the lowest frequencies, there was very little decrease in sensitivity from 500 kHz down to 100kHz. Even with high ambient noise and a modest Palomar amplifier/loop, there was enough sensitivity down in the 11 kHz area for me to detect at times the Omega navigational signals from North Dakota and Hawaii.

The HF-1000 without its preamp had about the same sensitivity as the RA-6790. (JG)

STABILITY

All fixed local oscillator frequencies and critical timing signals in the receiver are derived from a 10-MHz reference oscillator. The latter can be locked to an external oscillator's input of 1, 2, 5 or 10 MHz. The internal reference oscillator's stability is stated to be better than 1 part per million.

A convenient way for checking stability of a receiver like the HF-1000, with its single reference oscillator and precise BFO zero-setting capability, is to tune to WWV in the CW mode with BFO set at zero, find the exact frequency of zero-beat, and note any change in the frequency over time. I noticed no evident change in the zero-beat frequency, although this wasn't continually checked.

At 15 MHz, I found the oscillator in our HF-1000 to be off slightly, as indicated by zero beat for WWV. I registered zero beat at 15.000015 MHz. This suggested a 10 Hz error in the setting of the 10 MHz reference oscillator. There is normally a trimmer in such a receiver for making very small corrections to the oscillator's frequency, but I haven't noticed it mentioned in the manual. (JG)

DYNAMIC RANGE

Watkins-Johnson claims "High Dynamic Range: +30 dBm 3rd-order intercept typical." In the Manual, the company expands on this by stating the 3rd-order intercept point to be "+30 dBm typical, +25 dBm minimum (for signals separated by 20 kHz minimum)." Unfortunately, the measurement bandwidth is unstated.

Elton ('Bi') Byington commented on an article entitled "Key Components of Modern Receiver Design" by Dr. Ulrich L. Rohde, the first part of which appeared in the May 1994 issue of QST. Bi cited one feature of the HF-1000's design that would contribute to good dynamic range:

> *Rohde's argument centers around a receiver's AGC design and how it impacts on the set's dynamic range. He contends most modern radios are susceptible to intermodulation distortion because they derive their only AGC voltage from a point beyond their 2nd IF.*
>
> *In the article, Rohde argues persuasively for a two-section AGC system - one part controlling the 2nd IF's gain in a traditional manner, the other part controlling the gain of the first IF and the receiver's front end. His point is that intermodulation distortion can be produced at the set's 2nd mixer - and hence in the radio's second IF without its components having any effect. The argument is quite persuasive.*
>
> *Only two receivers I know of limit the gain of the first IF from a signal derived from the first IF itself: the Lowe HF-225 and the W-J HF-1000. Lowe uses a PIN diode to limit the gain of the first IF (45 MHz); the W-J uses a controlled bipolar amplifier.*

SYNCHRONOUS AM

The upgrade for synchronous AM was issued after our receiver try-out. It is of the double-sideband type. A W-J spokesman tells us that the pros and cons of double sideband and selectable sideband have been considered, and it is probable a future synchronous AM system will be of the selectable sideband type. We certainly endorse such a move.

PARAMETER	NRD + ESKA	HF-1000 + SAM
Weak signal lock range	+/- 20 Hz	+/- 250 Hz
Strong signal lock range	+/- 40 Hz	+/- 900 Hz

The following comment on the signal-lock performance of the present system was posted on Internet:

> *This past week I received the firmware for installing Synchronous AM (SAM) detection in my HF-1000 receiver. I was able to install it in about half an hour and it worked great. In testing it I compared it to the ESKA phase-lock AM board installed in my NRD-525. Here are the results for strong and weak signals.*
>
> *As an on-the-air test I tried to lock onto Radio Pyongyang, 13760 kHz, at 1300 UTC. The signal was weak and fading rapidly and was (actually) on 13760.1 kHz. The HF-1000 was able to lock onto it immediately even when set to 13760.000. The NRD was not able to lock it at all, even when set to 13760.1. Impressive!*- John Reed, KA5QEP

GAIN CONTROL MODES

Our test receiver had the standard control mode options available; Manual, AGC Fast and AGC Slow. The spec sheet's figure for typical attack time was 15 msec and for fast decay time, 25 msec. The slow decay rate was not specified.

Further specifications were: AGC range 100 dB minimum; Manual range greater than 100 dB. The AGC threshold was said to vary with bandwidth and was typically 10 dB above noise floor, being .56 microvolt for a 6 kHz width and .12 microvolt for a 300 Hz width.

Since our receiver try-out, Watkins-Johnson has released a firmware upgrade that provides a third AGC decay rate - Medium, an adjustable AGC-threshold mode in addition to the relatively fixed AGC threshold described above, and adjustable AGC-decay time. The following comment was posted on CompuServe:

AGC SETTING	DEFAULT DECAY TIME	RANGE LIMITS (USER-SELECTABLE)
FAST	20 msec	10-100 msec
MEDIUM	200 msec	100 msec - 1 sec
SLOW	2 sec	1 sec - 5 sec

It's interesting, and certainly more than a coincidence, that the HF-1000's AGC setup is now similar to the Racal 6790/GM - fast, medium, slow, manual, and fixed or adjustable threshold. I think you'll find that there's enough variation here to compensate for almost any signal condition you'll encounter.
- Steve Share

The HF-1000's upgrade, however, takes AGC flexibility farther than that in the Racal, a receiver whose design is about 15 years old.The HF-1000 owner can program in an AGC-decay time for each of three settings.The attack time of 15 msec is said to be unchanged.The decay times are as follows:

PASSBAND TUNING

This feature is limited to use while the receiver is in the CW mode and allows for a +/- 2 kHz shift relative to the passband. W-J has indicated a future upgrade will make available passband tuning in the SSB mode. The maximum shift will be increased for SSB, but we are told the exact limits have not yet been set.

TUNABLE IF NOTCH FILTER

In our test HF-1000, the filter appeared to be sufficiently deep for removing a strong heterodyne. The notch depth is said to be typically in excess of 60 dB. This is an impressive number, comparing favourably with the best IF notch arrangements in some earlier Drake, Collins and Hammarlund receivers of the past.

The function operates in the AM, FM, USB, LSB and ISB modes. The notch nominally can be adjusted +/- 9999 Hz relative to the tuned carrier frequency, although the actual tuning limits become progressively narrower as the bandwidth is narrowed. Either the Auxiliary Parameter edit knob or the numeric entry keys can be used to vary the relative notch frequency.

BFO FREQUENCY ENTRY

When the receiver is in the CW detection mode, the BFO entry key in the Auxiliary Parameter section can be activated to allow adjustment of the BFO frequency to anything within the range of +/ - 8000 Hz. Entry is made by the numeric entry keys or by adjustment of the Auxiliary Parameter edit knob. The ability to call into use a precise BFO frequency is especially useful for RTTY because the various frequency shifts that may be employed each call for a specific BFO frequency for best reception.

Repeated pressings of the +/- Zero Key cycle through three positions, either setting the existing BFO frequency above or below the carrier frequency, or setting the BFO frequency to zero.

SIGNAL LEVEL METER

The analog meter indicates signal strength both in 'S' units and in dBm (decibels referenced to 1 milliwatt). The scale range is -120 to +10 dBm, with the maximum on the 'S' scale being 80 dB over S9. The meter calibration is not affected by switching in either the preamplifier or the RF attenuator.

MEMORY CHANNELS

The HF-1000 has a capacity of 100 memories, or memory channels, as the manufacturer calls them. Memory backup is provided by an easily replaceable lithium battery.

To store a currently tuned frequency and other receiver parameters, it is a simple matter of first pressing the Channel View key on the left side of the front panel. Then, either the Memory/Scan edit knob or a numeric key entry for a particular channel, will bring the channel number and any existing frequency entered in the channel to the Memory/ Scan display. Once the desired memory channel is displayed, the user presses the Store Key to place the tuned frequency and other parameters into that memory.

For the reverse procedure, changing receiver parameters to those stored in a memory channel, the same steps are performed; pressing the Channel View key and using either the edit knob or a numeric key entry to bring up the memory channel to the display. Pressing the Channel Execute key updates the receiver with the parameters from the memory channel.

SCAN MODE

Three types of scan operations are available - memory channel scanning, frequency-to-frequency scanning, and frequency-to-frequency scanning with lockout frequencies inserted. For this latter type, the number of frequencies locked out can range in number up to 100.I n frequency-to-frequency scanning, the choice of frequency increment is within the range of 1 Hz to 25 kHz.

A Dwell key is used to set the time the receiver will pause at a signal before moving on. The time length can be from .5 to 20 seconds in duration or it can be infinite, i.e. until either the signal drops below the user-adjustable squelch threshold for 8 seconds, or the operator restarts the scan.

The first review of the HF-1000 in the commerical press that we are aware of appeared in the June 1994 issue of the British publication, *Short Wave Magazine.* The reviewer, Mike Richards, was especially enthused with the flexibility of the frequency scan mode for hunting down utility signals. Ease of use of the scanning modes also received high marks thanks to the user prompts in the menu system provided through the auxiliary displays.

BUILT-IN-TEST FUNCTION

The Built-in Test Function, or BITE, permits testing the internal circuitry of the receiver. A successful BITE test provides confidence that the receiver is performing normally. BITE is accessed and started with the Special Function key. Sixteen tests are performed.If all are successful, 'Bite Pass' is displayed; otherwise, a failure of any individual test registers as a specific number in the display. The meaning of each error code is described in the Manual.

AUDIO

The audio is clear and of good quality, although the *Short Wave Magazine* reviewer was somewhat disappointed with the measured distortion level through the speaker and headphone outputs. There are internal and external speaker, headphone and line outputs as follows:

Speaker: Level adjustable up to 1 watt into 8 ohms, with a bandwidth 100 Hz to 13 kHz, +/- 2 dB.
Headphone: Level adjustable up to 10 mW into 600 ohms; ¼ in. stereo jack. (This is an ideal match for the Japan Radio ST-3 communications phones used by many DXers.) Two unbalanced outputs with channelsfor USB and LSB in ISB mode; otherwise, outputs are combined.
Line: Level 0 dBm, or 1 mW, into 600 ohms. Two balanced outputs with channels for USB and LSB in ISB mode; otherwise, outputs are combined.

Bill Bowers pointed out to us that the internal speaker is not muted, even if the headphone jack is engaged or the external speaker connections are used. Since there are seperate speaker and headphone volume controls, this is not a problem when using headphones, provided the speaker volume is set at minimum output. However, the single speaker volume control governs the audio level for both the internal speaker and the external speaker outputs. This oversight interferes with the usefulness of adding a better quality external speaker.

Another convenience shortcoming is the absence of a tape recorder output although the 600 ohm line output works well for this purpose.

POWER SUPPLY

The receiver will automatically adjust to a connected power supply that is in the permissible range of 97 to 253 volts AC, 47 to 440 Hz. The power consumption with receiver options included is typically 35 watts. DC operation is not available.

RS-232 REMOTE OPERATION

The receiver can be controlled remotely by a computer or other controller device that is equipped with an RS-232 serial interface and capable of transmitting and receiving ASCII-standard encoded characters. Physically, only a transmit, a receive and a ground line are needed between controller and receiver. Twenty-nine different receiver parameters, ordinarily under local operator control, can be controlled or monitored over the RS-232 interface. There are 28 pages in the Manual explaining this form of remote operation.

CSMA REMOTE CONTROL

An alternate method of remote control, probably of much less interest among radio hobbyists, is through another interface type; Carrier Sense/Multiple Access with Collision Detection, or CSMA for short. This is a media access method whereby a number of stations, from 2 to 63, share a common line or bus medium. Eight receiver parameters can be remotely controlled.The Manual devotes a further 15 pages to this system.

REAR-PANEL CONNECTORS

On the rear panel are the following connectors:

Individual BNC connectors for RF input, HF-1000/PRE preselector input and output, signal monitor output,post-filtered IF output, reference oscillator input.
Mini-phone jack as CSMA remote interface port.
D-25 as RS-232C remote serial interface port.
D-15 for two 600-ohm audio line outputs, DC-coupled audio output, speaker output, remote signal strengthindication ouput, squelch output and mute input.
Grounded (three-prong) male receptacle for line cord.

The D-15 multi-pin plug is most inconvenient. The specifications pages in the Manual and the text in the marketing brochure indicates these outputs are provided by terminal strip (ie. screw terminals). That's what should have been provided but it isn't!

RF INTERFERENCE FROM DISPLAYS

Bill Bowers has performed some tests to measure the relative noise at mediumwave (812.7 kHz) and the 90 meter Tropical Band (3127 kHz) frequencies emitted by the digital displays of the HF-1000 and several other receivers. A Sony ICF-2010 (with 24 inch whip, in AM mode at wide selectivity and RF at maximum) was placed progressively farther away from the front face of each receiver to determine the distances in inches at which the Sony's signal-strength LED's went out (test #1) and further, when even the slightest audio noise ceased to be detectable (test #2).

In the following chart, lines one and two show the results of test #1 and test #2 respectively on Medium Wave for the subject receivers. Lines three and four correspondingly show the results of test #1 and test #2 on Tropical Band.

TEST	RA-6790	R-9000	R8	NRD-535	HF-1000
MW #1	8"	14"	1"	23"	17"
MW #2	21"	27"	4"	37"	23"
SW #1	4"	5"	0"	10"	11"
SW #2	13"	15"	4"	21"	16"

The clear winner in both tests on both frequencies is the Drake R8. Generally speaking, the Racal RA-6790 ranks 2nd. The HF-1000 and the Icom R-9000 can be seen to be in a close race for 3rd ranking, while the Japan Radio NRD-535 is slightly inferior still.

These tests should be taken into consideration by anyone considering using a loop antenna in the immediate proximity of the receiver, or indeed any form of antennae with unshielded lead-in.

Using at first an unshielded antenna lead-in, I thought the noise (radiated by the receiver and picked up by the antenna lead-in) from the HF-1000's displays was very low in both the AM broadcast band and in the shortwave spectrum up to about 11 MHz. It was from there to 30 MHz that the noise gradually increased, to the point where it exceeded weak signals. It seems necessary for any tuning in the higher frequencies to have a coax lead-in from an antenna. A W-J engineer told me they had had no indication at present that display noise is a particular problem. (JG)

My experience at my urban residence with an unshielded random wire was the same as James: severe hash was received at 10 MHz. It became progressively worse as the frequency increased. Furthermore, the blinking cursor associated with the frequency display was easily detectable at almost the same speed as the beat tones of WWV on 5 MHz. Perhaps there was some form of shielding fault specific to our test receiver? I should add, however, that none of these noise problems was experienced using coaxially-fed Beverage antennas at the DX barn on my rural property.(DC)

POSSIBLE FUTURE ENHANCEMENTS

Watkins-Johnson has confirmed the following enhancements are under consideration:

FSK Demodulation: This additional capability could be either an internal or outboard enhancement

Additional SSB bandwidths: Some owners have requested that the maximum IF bandwidth in the SSB modebe higher than the current limit of 3.2 kHz. The limit may simply be removed, making any width of up to 8kHz available for SSB use.

PC Signal Monitor: output for computer RF spectrum displays.

Adaptive audio filtering for automatic notching out of multiple heterodynes and for wideband "white noise"reduction. This would seem to be a "natural" for extension of the inherent DSP capabilities, to incorporate some of the features now provided by accessory units such as the NIR-10 and units in the line of DSP filtersfrom JPS Communications.

Speech compression for remote operation by modem.

We have been told that any of the last three enhancements may come about either by using the current DSP chip or an additional one. The capacity of the current chip is almost fully utilized but if the hobby community has little use for the reconstructed analog 455 kHz output, its removal could free up some capacity and permit an upgrade of the present chip to accomodate these changes. This approach would avoid having to put an additional daughter-board in the receiver, an alternative that could cost at least $700.

HF-1000/PRE: SUBOCTAVE PRESELECTOR OPTION

This optional filter device mounts inside the rear wall of the receiver's chassis. The preselector filters unwanted out-of-band energy from the RF applied to the receiver and therefore might be a worthy addition for anyone operating from an especially high signal level environment.

Each one of eleven filters covers a part of the RF spectrum in the range of 0 MHz to 30 MHz. The receiver's tuned frequency determines the selection of the appropriate filter which improves the receiver's second and third intercept performance. The preselector also features two RF voltage overload-protection circuits.

CONCLUSION

Our early impression is that the HF-1000 is a worthy purchase for the well-heeled hobbyist who must have the "latest and greatest", especially given the enhancements added since our test. In side-by-side comparisons with James' RA-6790 and David's R8, however, we found no significant differences in tough-signal "DX-ability", except for utility modes. Certainly the array of IF filters with their outstanding skirt selectivity characteristics is a major advance. But from a DXer's perspective, similar reception capabilities can be attained from other "conventional" top-end receivers like the NRD-535D and the R8, albeit sometimes with a bit more "knob twiddling". The value for the current pricetag of the HF-1000 is debatable. We would like to think that as has been the case with most new and emerging technologies, the price of DSP chips could come down significantly. It might be worth a wait.

On the other hand, we hope the HF-1000 continues to sell well as it apparently is. It would be a pity if a quality outfit like Watkins-Johnson was discouraged from developing a presence in the hobby marketplace. W-J has already established a good reputation for its interest in and responsiveness to user feedback, so all indications are very positive.

Universal Radio in Reynoldsburg, Ohio quotes the HF-1000 at $3,799. The optional preselector is priced at $599.95. In Canada, Norham Radio in Toronto, Ontario quoted the Canadian funds price at $5,200 based on the prevailing exchange rate for the US dollar. A Canadians funds price for the preselector was not available.

UPDATE:

MORE ON THE WATKINS-JOHNSON HF-1000 RECEIVER

(Current Version as of August, 1994)

Submitted by: **George Zeller** Compiled by: **David Clark**

Editor's Note: *The appearance of the HF-1000 in the fall of 1993 caused such a stir in the marketplace that we resolved to provide an "early" review in this issue of Proceedings. The preceding article by David Clark and James Goodwin was necessarily captioned a "first impressions" review. In late-winter 1994, they had time-limited use of an early version HF-1000 on loan from the Canadian dealer. Since then, e-prom upgrades have been implemented which enhanced the AGC capabilities and delivered the planned synchronous AM capability.*

In midsummer 1994, George Zeller acquired a new HF-1000 which incorporated all of the more recent e-prom upgrades. He also purchased the optional preselector to ensure optimal front-end performance. Just before Proceedings 1994-95 was going to press, George informally shared his more extensive findings and insights with us, including perspectives based on his own direct dialogue with Watkins-Johnson. The editorial staff are grateful for George's authorization to compile this timely and highly useful Update for inclusion in this edition.

OVERVIEW

Let's begin with two very important statements. First, I believe this receiver dramatically outclasses every other receiver in the consumer shortwave radio marketplace, regardless of price. I am absolutely delighted with it so far! I want to emphasize that the relatively few problems I have identified and my suggestions for improvements should not be construed as detracting from my overall enthusiasm for the product.

Second, Watkins-Johnson is to be commended for their open policy of communication with their customers. When I called the '800' number, I was treated in a very friendly fashion while Michael Cox of the W-J Engineering Department was on another line. I then enjoyed a half-hour conversation with Mr. Cox who was very friendly and helpful. I have since sent him a lengthy letter which outlines my findings and recommendations based on the month or so of experience that I have had with the receiver. I am confident I can anticipate a constructive response in due course.

My comments begin by highlighting just some of the many outstanding features of the HF-1000. Then I outline the more significant deficiencies or shortcomings that I have found. These findings form the basis of a longer "wish list" of suggestions for future upgrades. I believe these suggestions merit and probably will receive serious consideration by W-J. Finally, I have compiled a list of further "nice-to-have" enhancements that may not be feasible to implement based on practical memory limitations and/or the physical design of the HF-1000.

OUTSTANDING FEATURES

Any discussion of the HF-1000 must start with the 58 IF filters which all seem to have nearly vertical shape factors. These DSP-derived filters are the principle technological breakthrough that places the HF-1000 in a class by itself.

But there are other unique features that deserve strong kudos. The BFO, Notch, and Step Tune are adjustable to a resolution as fine as 1 Hz, with corresponding readout on the front panel display. The frequency readout is available to 1 Hz resolution as well. The PBT is adjustable to 10 Hz resolution although it is only operative in CW mode. The threshold levels of the three AGC positions (plus Off) are adjustable as well. The ten-position Noise Blanker is very effective. No other receiver has this combination of features and flexibility. They are wonderful.

The general performance of the receiver is better than I have experienced with any other radio. The sensitivity is very good and has been found to be better than the ICOM R-9000 is some 'A-B' tests I did with a single antenna. The front end seems to be built like a battleship. I do have the optional preselector installed and have not noticed any stray signals. Dynamic range and blocking seem superior to other receivers I have used. The acid test for me is the nightly situation on 7415 kHz which I tune for pirate DXing purposes. When WEWN signs on 7425 kHz with its very powerful 500 kW signal and broadband slop, my other receivers can't handle the mess. I can get rid of WEWN on 7415 kHz entirely in LSB mode with the HF-1000.

The memories are all tunable and you can tune between the memories with a knob. This is a very useful feature that I haven't seen on other current receivers except the Japan Radio NRD-535D. The Drake R8 tunes between the memories but the memories themselves are not tunable.

The layout of the front panel is pretty good. It didn't take too long to learn how everything works and general ergonomics are good. Functions and displays are spread out over a lot of space, so you really can't push the wrong buttons by mistake. The owner's manual is extremely good. It is clearly written, comprehensive and includes schematics, parts list and computer control parameters. The General Binding spiral binder is good for adding future manual update pages.

I think the audio is very good, especially in the AM synchronous mode which is the latest software upgrade and has been implemented in the model I purchased. Audio is better than that of the R-9000 which is also very good. It rivals the audio quality delivered by the Philips DC-777 shortwave car radio which, in my opinion, has the best audio of any current shortwave receiver. This seems to be mainly a result of the filter flexibility and the synchronous detector, although audio is quite good in single sideband mode too. I will modify this assessment with later remarks concerning audio hiss and the internal speaker that cannot be disabled.

Taken collectively, all of these flexible features and functions mean that there is no better shortwave receiver currently for sale, although it certainly is expensive. I don't believe any other receiver even approaches the level of capability of the HF-1000. It is a great technological breakthrough in useful DX performance. In fact, I am running out of adjectives to describe its literally astonishing overall performance characteristics.

THE BAD NEWS

Aside from the enormous price-tag which unfortunately places prospective ownership of the receiver beyond a large majority in the shortwave receiver consumer market, I have identified five aspects that I feel can be classified as definite flaws, although only one is really serious. Of these, the first four are problematic, so I do hope W-J will give some thought to fixes, most importantly with respect to the digital hash characteristic that David Clark and James Goodwin identified in their review. The fifth flaw is less salient but nevertheless, it is a problem.

1. DIGITAL HASH: The receiver puts out a very unfortunate level of digital computer hash noise. It seems to come from the front panel but W-J says that their probes indicate the problem may originate with the e-prom that drives the front panel. The condition makes it difficult to use an indoor medium wave loop antenna such as the Kiwa model that I have in the immediate proximity of the receiver. It also creates serious shielding problems for feedlines from outside antennas (see also 3. following). Although evidence of the hash is certainly a concern on the lower frequencies, I should add that it is much worse on frequencies above 12 MHz.

This is the worst fault with the HF-1000 by far...the one really significant blemish on an otherwise super receiver. If the problem indeed lies with the e-prom, this might just be a question of providing improved shielding.

2. SOFTWARE FAILURE: On one occasion the memories suddenly went dead and after a couple of minutes, the entire receiver seized up. A strange 26 MHz frequency appeared on the display but otherwise, all other panel indicators were frozen in the initialization mode. No knobs or buttons worked and there was no audio output. Turning the receiver off and then on again started a new initialization cycle (analogous to a "soft boot" on a computer) which terminated in the same frozen condition.

Fortunately there is a cold start ("hard boot") mode programmed into the receiver software. This is invoked by depressing the Clear/Entry key at the same time the receiver is powered on. When this was invoked, normal operation resumed, except that all memories and other settings were not retained. The receiver returned to default mode as it comes out of the box. Apart from this one incident, it has worked perfectly ever since. The sequence of events has been communicated to W-J and their diagnosis is hopefully going to identify and resolve the presumed software bug.

3. BIRDIES: In normal use, I find there are dozens of birdies in the receiver. The worst of them are concentrated in or near the 20 meter ham band and the 31 meter SWBC band. The birdies sound like the digital hash and are present in two categories; those which are extremely strong and others which are not as strong but still very noticeable. The extremely strong ones have been found at 3500, 8000, 11200, 11400, 12400, 12800, 13200, 14000, 14400, 14800, 16000, 17600, 24000, 28000 and 30000 kHz. The other audibly bothersome group have been located at 7000, 10800, 11500, 11600, 11700, 11800, 11900, 12000, 12500, 12600, 12700, 13000, 13100, 13300, 13500, 13600, 13800, 13900, 14300, 14500, 14600, 14700 and 18000 kHz.

There is a significant difference between the two categories. The extremely strong birdies are audible, albeit weaker, when no antenna is connected. The second category disappear when the antenna is disconnected but reappear when the antenna is again connected to the receiver. So it seems that the birdies are a by-product of the digital hash which is apparently being reradiated into the receiver, even through a coaxial antenna lead-in. A better internal shielding arrangement is an imperative.

4. AUDIO HISS: It is strange that the HF-1000 exhibits two of the problems that plagued the Japan Radio NRD-525; digital hash and hiss noise in the audio output. The hiss is not nearly as bad in the HF-1000 but it is nonetheless audibly noticeable and distracting, especially when using headphones. The level seems to be related to the filter in use; the hiss is more bothersome when a wider filter is used.

While the fault is not nearly as serious as the digital hash interference, it is something to be concerned about. The addition of a DSP audio processor ought to resolve this annoying problem.

5. AUDIO 'OUT' IDIOSYNCRASIES: The multipurpose A2J16 pin output is utterly nonstandard in the radio hobby. Fortunately, I spotted this before I purchased the receiver from Universal Shortwave. They soldered some connectors to the pin plug for me. I now have two RCA jacks for the USB/LSB/ISB audio out. I also have the external speaker audio out wired to a 1/4" plug which in my case is used to drive an M-8000 RTTY decoder.

The audio through the small, internal speaker is quite poor. I was then annoyed to find that the audio to this speaker cannot be disabled, even when an external speaker is engaged.

The independent AF gain control for the headphones is a very nice touch, although here the adjustment range of the gain control could be improved; it has to be turned up well-past the halfway point before adequate volume is received through the headphones.

UPGRADES NEEDED - WISH LIST

It is understood that the memory capacity on the present DSP chip is almost exhausted. This means that in the absence of, or pending an expensive ($700-1000 range) major upgrade, some software upgrades might have to come at the expense of removing some of the existing features. I have a few observations in this regard.

I am not using the IF out provision so I probably wouldn't miss it unless it was to be used for an external spectrum display. I do find the "false stereo" effect of the ISB mode on an AM signal to be an interesting novelty. In some cases it seems to provide the most usable copy of a DX signal so I would be reluctant to lose that mode.

If a proposed selectable sideband AM synchronous detector works as well as the present double-sideband version, then I would be interested. But if that degraded the wonderful audio delivered by the current implementation, then I would certainly not want to lose it. I understand as well from talking with W-J that expanding the range of filters available for SSB mode would consume significant additional memory.

Taking these caveats into account, as well as the more serious problems I have identified, following is my current wish list of needed and strongly recommended upgrades.

1. Fix the Digital Hash: Since this is the only really serious problem with the receiver, improved shielding or other modifications to deal with it should be the number one priority. My experience indicates that if this was to be resolved, the numerous strong birdies would be greatly attenuated as well.

2. Provide DSP Audio Processing: It is understood that provision has been made for the future extension of DSP to the audio stage. This would seem to be a "natural" for expansion of the already impressive DSP utilization. It ought to be a significant improvement since it would surely eliminate the hiss noise currently noticeable in the audio output.

3. Enable PBT in Sideband Modes: I can't understand why the PBT only functions in CW mode. Many DXers, including myself, frequently do a lot of tuning and DX listening in sideband modes, including ECSS reception of AM signals. PBT is often useful for interference rejection and often obviates the need for a filter that is too narrow for reasonable audio reproduction. For this proposed implementation, the present PBT tuning range (+/- 2 kHz) should be expanded to +/- 3 or 4 kHz.

4. Enable Wider Filters in Sideband Modes: It seems strange that AM and CW can be received at any filter bandwidth, yet SSB reception is limited to the filters within the range of .9 to 3.2 kHz. It is recognized that a 3.2 sideband bandwidth renders about as much audio as a 6 kHz filter in AM mode, but expanded provision for filters wider than 3.2 kHz would still be desirable, especially when toggling between AM sync and SSB modes.

5. Provide Selectable Sideband AM Synchronous Mode: As noted, there are times when user-selectable upper or lower sideband selection is desirable for optimum ECSS reception. The present double sideband implementation, as provided for example in the Lowe HF-225/Europa, should be retained if possible. Maximum flexibility would be great if provision could be made for selectable sideband as well, as has been implemented for example in the Lowe HF-150.

6. Resolve Audio Out Deficiencies: There are four issues here. The pin connector should be replaced with a terminal strip or by providing of an adaptor that allows an array of pre-wired RCA audio jack outputs to be plugged into the connector. Next, the internal speaker should be automatically disengaged (or switch selectable) when the external speaker out is connected. Improve the "balance" across the range of the headphone volume control. Finally, the front panel switch to regulate 'USB/LSB/ISB Out' only affects the audio output to the external speaker output via the connector. It doesn't work with either the headphones or the internal speaker. Given that my external speaker out is used for the RTTY reader, I get no use at all from the switch as currently configured.

IT WOULD BE NICE...

Here are other items on my current "wish list", although these are mostly in the convenience improvement category, some probably limited by the front panel design, and certainly noncritical to the performance of the receiver.

1. Spectrum Display: I find a valuable feature of the ICOM R-9000 is its very user friendly and virtually real time spectrum display. As there is no built-in CRT display in the HF-1000, I suppose any spectrum analysis capability would need to be handled by an outboard device via the IF out.

2. Programmable Alpha-Numeric Memory Designations: A number of receivers, including portables such as the Sony SW-55 & 77 and certain Grundig models, allow the user to program an alphanumeric designation for each memory channel. This would be a convenient addition to the HF-1000's capabilities but I'm not sure how display might be handled on the front panel.

3. Another 100 Memories: Like the Drake R8, the HF-1000 only provides capacity for 100 memories. Many of the better receivers today provide 200 or more memory channels. The addition of another 100 (tunable) memories would be useful for some owners, especially those who like to take advantage of the complementary scanning functions.

4. Mode Buttons: Most users are very annoyed by carousel-style mode change buttons. The worst offender in this regard is the Drake R8. At least with the HF-1000, the carousel is bidirectional so it is relatively easy to toggle back and forth between the USB and LSB modes but the design is inconvenient for invoking offsets in CW, RTTY and FAX modes. The ICOM R-9000 arrangement of individual buttons for each mode is a superior design but I don't know where individual mode selection buttons would go on the existing HF-1000 front panel.

5. Keypad Format: The familiar touch-tone telephone keypad sequential numeric format with zero and other entry functions on the lowest row is provided on most shortwave receivers which provide keypad entry facilities. The inverted format of the HF-1000 keypad takes some getting used to. Is this a leftover from a military or commercial standard?

6. Improved Smoothness for the Main Tuning Knob: The feel of the main tuning knob "wheel", as it is dubbed in the Owner's Manual, is quite stiff. This may seem minor but during long DXing sessions, a comfortable feel such as that rendered by the Drake R8 is important. Using the big knob on the HF-1000 feels like turning the main wheel on an ocean liner. Maybe it needs a dose of power steering!

7. S-unit Conversion: The dBm calibration on the signal strength meter is interesting, seems precise, and fortunately is precisely correlated with the dBm units governing the Squelch control. But this unit of measurement is non-standard in the radio hobby. Most other good receivers contain S-meters or equivalent graphical displays that are calibrated in S-units and decibels over S-9. Apart from converting to an S-meter, a simple conversion chart defining equivalent S-units in microvolts that could be inserted into the Owner's Manual would be a valuable "no cost" service to most purchasers.