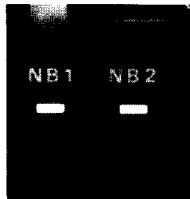




## (G) Noise Blanker Circuitry

Two noise blankers are provided in the FT-1000MP, for coping with different types of noise encountered on the HF bands.

With the demise of the Soviet Union, the notorious "Woodpecker" noise associated with the USSR's over-the-horizon radar systems has essentially vanished (except for sporadic testing). However, the design parameters associated with the "Woodpecker Blanker" circuits developed over the past two decades have proven to be highly effective against many types of commonly-encountered wide-pulse noise sources. In the FT-1000MP, the twin Noise Blankers—NB1 for narrow-duration pulses and NB2 for long-duration pulses—provide the operator with a choice of blanking tools.



The IF Noise Blanker circuitry utilized in the FT-1000MP is fundamentally similar in concept to blanker designs used for many years in Yaesu and other transceivers. In this technique, noise pulses detected in the receiver passband are converted to a DC voltage, which, in turn, controls a "gate" device later in the IF, which places a very short duration "gap" in the IF signal at exactly the point where the noise pulse is present.

This technique has been the only one available for many decades. It can be very effective, but with excessive blanking action it can cause distortion; moreover, if the noise pulse is not well-defined (low amplitude or wide duration), the pulse-detection circuits sometimes cannot "grab ahold" of the pulse, rectify it, and send an effective control signal to the gate device.

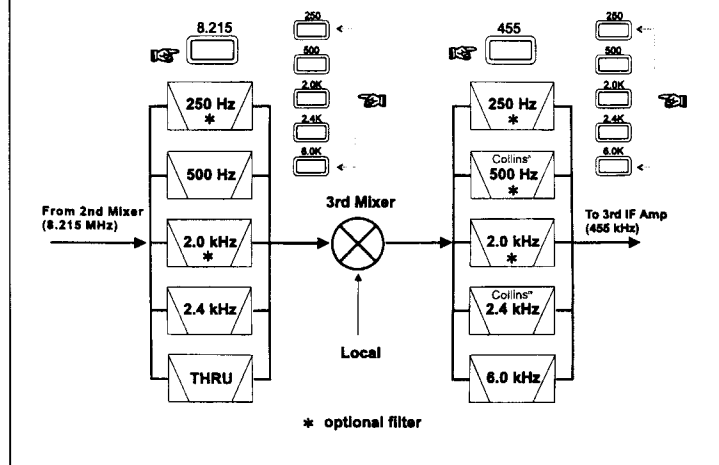
With the introduction of EDSP, however, this traditional analog design can be used in conjunction with the EDSP noise reduction circuits. Unlike the analog noise blanker, which seeks pulses and then blanks them, the EDSP looks for any energy which is not a "desirable" signal, such as voice or CW, and then seeks to eliminate it. In the frequently-encountered situations where poorly-defined pulses or multiple out-of-phase pulses are present, the combination of analog IF and EDSP noise reduction will provide significantly better signal-to-noise ratio than will either technique alone. Moreover, the presence of the EDSP noise reduction allows less aggressive IF noise blanking to be used, so as to minimize distortion effects, with the EDSP Noise Reduction selections performing the "clean up" task that previously could only be accomplished by engaging the IF noise blanker fully (often leading to distortion in the desired signals).

The EDSP Noise Reduction circuitry provides an additional benefit. Its adaptive-filter characteristics cause a "shaping" of the EDSP passband to match the frequency response of the incoming signal. As one tunes across a voice sub-band with Noise Reduction activated, the pitch of the background noise will appear to change every time a new signal is encountered, as the EDSP analyzes the signal and adapts itself to the voice characteristics; a bassy voice will shift the response slightly lower, while a female voice will shift the response higher. The result is greater net noise power reduction, thanks to the adaptive shaping which "form fits" the noise reduction effort around the (current) incoming signal waveform. Re-set time for a new voice pattern encountered as one tunes is, of course, virtually instantaneous thanks to the fast processing time of the EDSP's IC.

## (H) IF Main Selectivity Filters

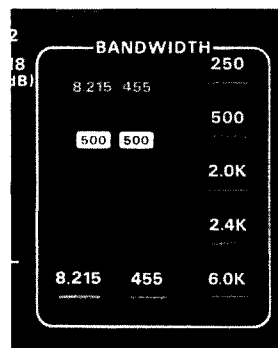
Although the stock 2.4 kHz and 500 Hz IF filters are quite satisfactory for general operation, the FT-1000MP includes provision for the selection of as many as twelve different filters, if all available options are installed in the 8.215 MHz and 455 kHz IFs in the Main and Sub receivers. For world-class contest or DX-pedition use, these filters constitute the most comprehensive and easy-to-use array of IF filters ever assembled in an amateur radio transceiver.

**Fig.2-4 Main Receiver (VFO) IF Bandwidth Filter Selections**



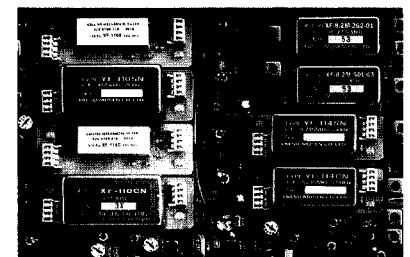
To provide the most flexibility in selecting these filters for the operating circumstances encountered, an ergonomically-designed matrix of seven selectivity-determining switches is used. Two of these determine the IF whose filter is to be changed; the other five determine the bandwidth. If the operator wishes to set a 500 Hz bandwidth for both cascaded filters, the "500" key is pushed once; if, on the other hand, you wish to set the 8.215 MHz IF to 2.0 kHz and the 455 kHz IF to 500 Hz, simply press [8.215]→[2.0K]→[455]→[500]. Filter selections, once completed, are retained in each VFO and memory register (along with mode), so you can set up a 20-meter SSB register with 2.4 kHz bandwidth alongside a 20-meter CW register with 250 Hz bandwidth. Some competing units have no provision for retention of bandwidth information in VFO and memory registers.

The IF filters used in the FT-1000MP are carefully specified, each providing ultimate attenuation of at least 80 dB. Meticulous back-bias of the switching diodes, along with careful mechanical design of the IF Unit's ground plane, provide outstanding isolation between filters, along with negligible bleed-through. The filter stages are gain-balanced, so as to keep receiver gain constant when changing bandwidths.

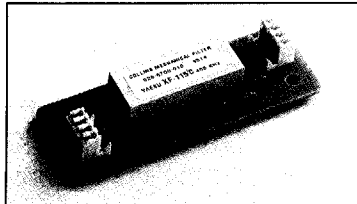


### ◀ BANDWIDTH SWITCH

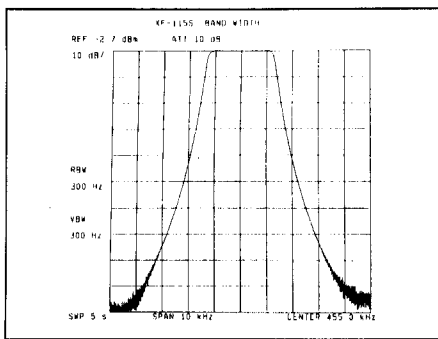
### ▼ FILTER LAYOUT



A highlight of the IF filter complement is the inclusion of the new-technology Collins® Mechanical Filters into the design of the FT-1000MP. A 455 kHz 2.75 kHz-bandwidth Mechanical Filter is standard equipment, while 455 kHz 500 Hz-bandwidth filters are available options for the Main and Sub receivers. Collins® Mechanical Filters are vastly superior to the usual ceramic filters which are often used at the end of an IF chain for noise reduction, in that they have negligible phase distortion, an extraordinarily flat “nose-on” passband (ripple typically  $\leq 0.1$  dB), and outstanding ultimate attenuation. The flatness throughout the desired passband means that the bandwidth of the mechanical filter will usually be wider at the -6 dB points than is a ceramic or crystal filter of identical bandwidth specification, yet the -60 dB bandwidth will likely be narrower. This provides better fidelity and more natural reproduction of the operator's voice pattern.



**Fig.2-5**  
Collins® MECHANICAL FILTER PASSBAND RESPONSE (SSB FILTER)



## (I) IF Amplifiers

The characteristics of the main IF chain in any receiver are critical to the net system performance of the design. The FT-1000MP utilizes the proven design of the FT-1000D, featuring low-noise 3SK131 MOS FET transistors as the main amplification devices. The IF design was executed using a comprehensive and sophisticated computer program which allows careful scrutiny of such critical parameters as gain, noise figure, and dynamic range, and which allows evaluation of the effects on system performance due to temperature and input signal level variations.

In the manufacturing process, this design data is utilized in conjunction with the computer-based alignment protocols of the production line, and each transceiver is individually optimized for specified receiver system gain, ensuring a high level of consistency in finished products as they exit the production line.

## (J) (Analog) Detection Circuits

Three analog detection techniques are used to convert the 455 kHz IF signal to audio at the end of the IF chain:

### • SSB Product Detector

The  $\mu$ PC1037H product detector IC provides outstanding thermal stability and balance, addressing common problems found in discrete-diode product detectors.

### • AM Detector Circuit

Both envelope detection and synchronous detection are facilitated by the MC13020 AM detector IC. In the synchronous detection mode, a 455 kHz VCO is locked onto the carrier frequency of the received signal by a PLL circuit. Then, by concentrating on the carrier and one sideband during synchronous reception, AM distortion due to phase differences in the upper and lower sidebands is eliminated. If, due to fading, phase lock is lost on the incoming signal, the receiver instantaneously reverts to envelope detection.

### • FM Detector Circuit

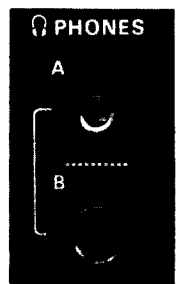
An FM subsystem IC, type MC3372, is used to provide high-quality narrow-band FM reception. The bandwidth of this system, at 6 dB down, is 8 kHz.

## (K) Receiver Audio Circuits

The demodulated analog audio signals are passed through an active low-pass filter, the response of which is optimized for the mode (and corresponding IF bandwidth) in use. Particularly on CW, this audio bandwidth optimization ensures that noise figure is not degraded (due to excessively broad audio bandwidth) when a narrow IF filter bandwidth is utilized.

The audio output level to the headphones or speaker is varied by a low-noise voltage-stepping volume control similar to the type used in high-fidelity audio equipment. The design was accomplished so as to minimize noise pickup by eliminating the routing of the audio signal itself to the front panel Volume control, as well as to make the level steps indistinguishable to the operator.

Headphone audio is fed through a dedicated headphone-audio amplifier stage, which provides independent output for the Main and Sub receivers, thus minimizing “suck-out” loss during Dual Receive operation. Either full stereo, monaural, or “mixed” audio (left/right emphasis for Main and Sub audio, but not complete isolation) can be selected. Both 3.5mm and 1/4” stereo headphone plugs may be used, and it is easy, for example, for two operators using two sets of headphones to use the FT-1000MP in a Dual Receive configuration, each operator covering, for example, a different segment of a pile-up during DX-pedition use.



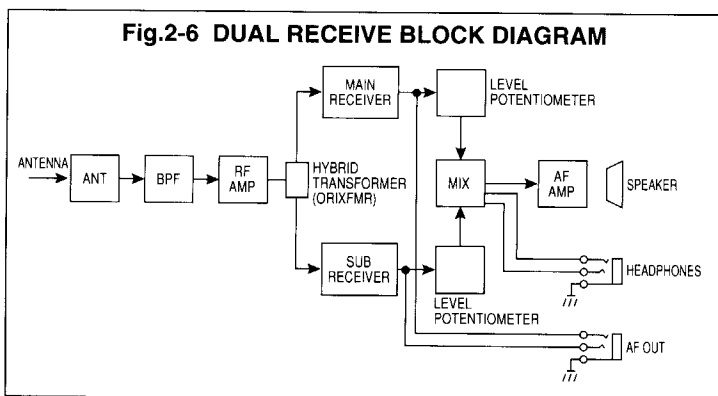
The built-in speaker includes a large magnet for high-quality sound reproduction, even at loud volume levels.

## (L) Sophisticated Dual Receive System

The Dual Receive system architecture, widely acclaimed on the FT-1000D, was developed specifically with the DX and contest operator in mind. Utilizing two large tuning knobs, independent Volume and Squelch controls, as well as simple frequency and mode selection with clear displays for each receive frequency, the Dual Receive system makes “Split” operation in DX pile-ups simple and efficient.

For example, the operator may search a pile-up for the station in QSO with the DX, while also listening to the DX station so as to allow precise timing of calls to the DX station. In contest operation, the Dual Receive system allows the operator to “watch” a multiplier on the current band, or it may be used to establish and hold two “CQ” frequencies (for example, at the low end and at the high end of the band) during slow times of a contest; with one touch of the VFO selector, the transmitter will be switched back and forth between the two frequencies; with audio from the two frequencies isolated in stereo headphones, it is easy to determine instantly the VFO on which a response is heard.

New features of the FT-1000MP Dual Receive system are AF Reverse (to compensate for reversed wiring of headphones), the one-touch illuminated VFO selector keys, and VFO tracking.



### (M) Independent Sub Receiver Unit

An essential element of the FT-1000MP's Dual Receive system architecture is the Sub Receiver Unit.

The Sub Receiver is a double-conversion superheterodyne design, using up-conversion to a 47 MHz first IF. Because the Sub Receiver is completely independent from the Main Receiver, the AGC circuitry of the Main Receiver does not affect the Sub Receiver (and vice versa), so strong signals on one receiver do not “pump” the other receiver. Moreover, different IF filters may be selected in the two receivers, allowing a DX operator to listen, for example, in a 250 Hz bandwidth on the Main VFO (to isolate the desired DX station) yet listen in 2.4 kHz bandwidth on the Sub Receiver to search through the pileup for an optimum calling frequency.

It also is possible to operate in different modes on the two registers, so the Sub Receiver may be used for monitoring of a 10 MHz DX packet station while the operator tunes elsewhere in the band on CW in a narrower bandwidth. New on the FT-1000MP Sub Receiver is the elimination of mode/filter restrictions for RTTY operation, so it is possible to use a 500 Hz filter on the Sub Receiver for AFSK operation.

Both 6 kHz and 2.4 kHz ceramic filters are utilized as standard equipment in the Sub Receiver, and the optional 500 Hz Collins® Mechanical Filter may be added for improved CW and Data selectivity. Utilizing the newly-developed Direct Digital Synthesis (DDS) IC (described later), tuning steps as fine as 0.625 Hz may be selected, allowing very precise tuning for critical Packet and other Data applications.

On transmit, the Sub Receiver acts as an RF Monitor, allowing the operator to hear actual “on the air” results of bandwidth and other adjustments of the EDSP and/or microphone equalization during voice transmission, as well as the effects of CW timing adjustments in that mode. The DDS automatically slaves the Sub Receiver to the current transmit register's frequency, ensuring zero-offset precision on the RF monitor.

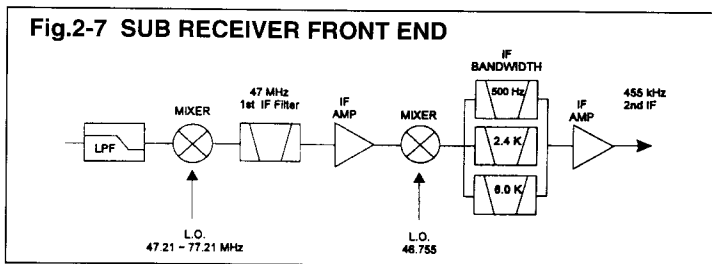
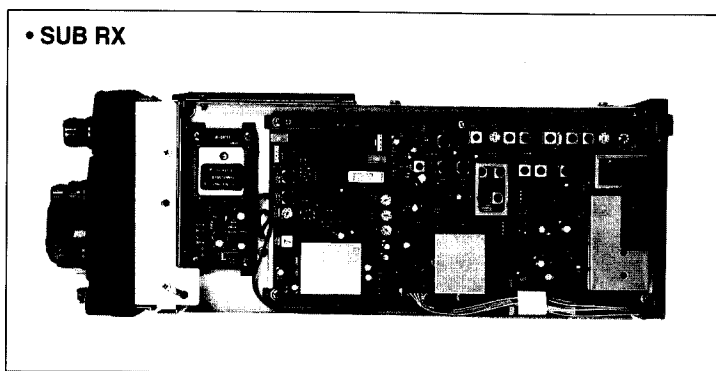


Table 2-3 Sub Receiver AGC Selections (Menu Item 8-7)

MENU	COMMENT
AUTO	MODE-DEPENDENT AGC SELECTION
SLo	SLOW AGC RECOVERY TIME
FAST	FAST AGC RECOVERY TIME



### (N) Comprehensive Interference-Removing Features

The FT-1000MP is equipped with the most complete and comprehensive array of interference-removing features every assembled in an amateur radio transceiver. The design philosophy of the FT-1000MP incorporates filtering and other interference-reduction features throughout the receiver signal path, beginning with the High-Pass and Band-Pass filters in the 70 MHz first IF, and culminating with the EDSP filters late in the receiver.

Besides the standard and optional IF crystal, mechanical, and ceramic filters, there are several specialized interference-reduction tools utilized in the FT-1000MP:

#### ① Analog Processing

The IF WIDTH, IF SHIFT, and IF NOTCH filter circuits of the Main Receiver all bring special capabilities to the operator, allowing interference to be combated in different ways.

#### • IF SHIFT

The IF SHIFT function tunes the signal across the passband of the IF filter electrically without changing the pitch of the signal and without changing the bandwidth of the IF, by shifting the frequencies of two local oscillators simultaneously. This allows either high-side or low-side interference to be rolled off quickly and efficiently.

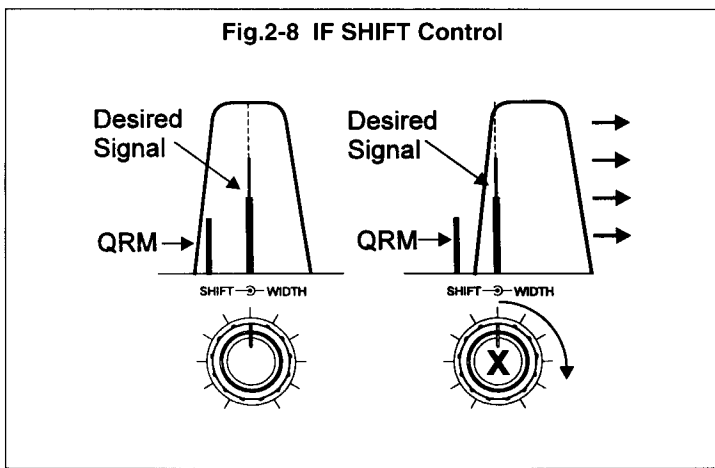
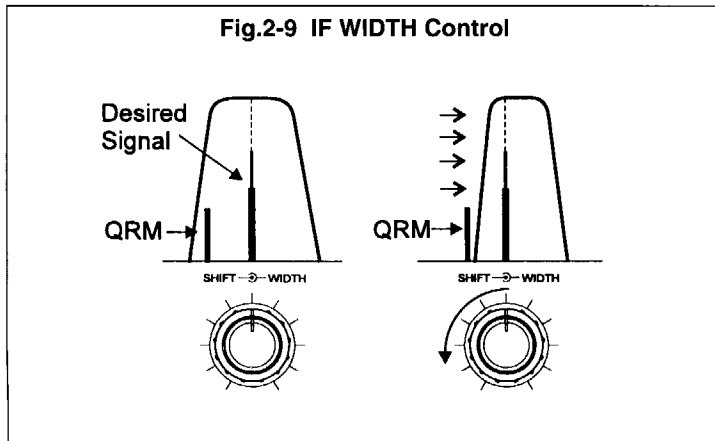


Table 2-4 IF SHIFT/WIDTH Resolution (Menu Item 1-2)

DISPLAY	10 (NORMAL)	20
STEP RESOLUTION	10Hz	10Hz
RECOMMENDED USE	BEST FOR FINE TUNING ON CW	BEST FOR SSB OR WIDE FILTER USE

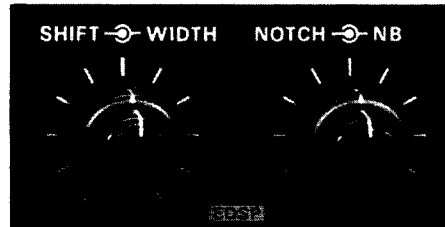
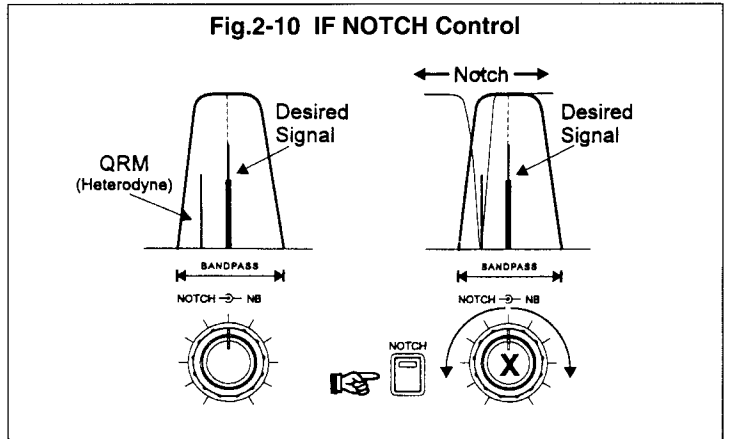
• IF WIDTH

The IF WIDTH function utilizes the cascaded filters in the 8.215 MHz and 455 kHz IFs. By varying the frequencies of the local oscillators for these IFs, the two filters' passbands are "squeezed" against each other, providing variation of the IF bandwidth from about 1.2 kHz to 2.4 kHz in SSB, or 0 Hz to 500 Hz on CW. IF WIDTH function is most effective when full banks of optional IF filters are installed.



• IF NOTCH

The 455 kHz IF includes a high-Q Notch function, which allows the operator to notch out strong carriers interfering with the desired signal. The NOTCH function is particularly spectacular when both the IF NOTCH and EDSP NOTCH filters are engaged simultaneously.



② EDSP Processing

The bandwidth of the Band-Pass Filter in the EDSP (the first counter-clockwise position in the EDSP Contour control) can be set and optimized for each mode. For example, the CW EDSP passband may be set to 120 Hz, while the SSB passband may be set to 2.38 kHz! With very sharp skirt selectivity, the EDSP filters, positioned near the end of the receiver signal path, provide the final "clean-up" of any residual interference, and the EDSP NOTCH function, as mentioned previously, can be used to eliminate any remaining beat notes in the passband.

3. Transmitter Design Highlights

Both analog and digital modulator circuits are provided in the FT-1000MP, along with transmitter gain compensation, the Collins® Mechanical Filter in the 455 kHz IF, and a refined RF Speech Processor. The result is outstanding transmitted signal clarity and pile-up "punch" when you need it most.

(A) Microphone Amplifier Stage

Just as in a receiver design, the earliest stage of the transmit signal path is critical in establishing maximum signal-to-noise ratio and dynamic range on the voice signal. Whether analog or digital modulation is to be used, it must be recognized that the human voice

has a total dynamic range of 90 dB or more in close proximity to a microphone element. Therefore, simple general-purpose microphone amplifier ICs are not adequate for this application.

The FT-1000MP incorporates a low-noise microphone amplifier stage using bipolar transistors, as on the FT-1000D, to obtain the required 90+ dB of Signal-to-Noise ratio on the voice signal. The MIC GAIN control is a voltage-stepping potentiometer similar to that used for receive audio, and it eliminates the possibility of noise pickup on an audio line routed through a front panel potentiometer; instead, the signal path remains on the AF Unit, shielded from noises which might be generated elsewhere in the transceiver.

Careful ALC design, and the application of EDSP microphone equalization, both contribute to the maintenance of high Signal-to-Noise ratio early in the voice signal generation process.

### (B) Analog Modulator/Mixer and Transmit IF Stages

A balanced modulator circuit featuring the Yaesu-exclusive  $\mu$ PC1037H converts the incoming microphone signal (either analog audio or the 10.24 kHz EDSP digital voice signal) to the first transmit IF of 455 kHz. The  $\mu$ PC1037H has superb thermal stability, outstanding resistance to carrier leakage, and high Signal-to-Noise ratio and dynamic range.

The transmit signal, subsequently mixed first to 70 MHz and thence to the final transmitting frequency, is carefully controlled for gain, so as to ensure that overdrive of the IF or power amplifier stages does not occur, either during thermal changes or with varying output power.

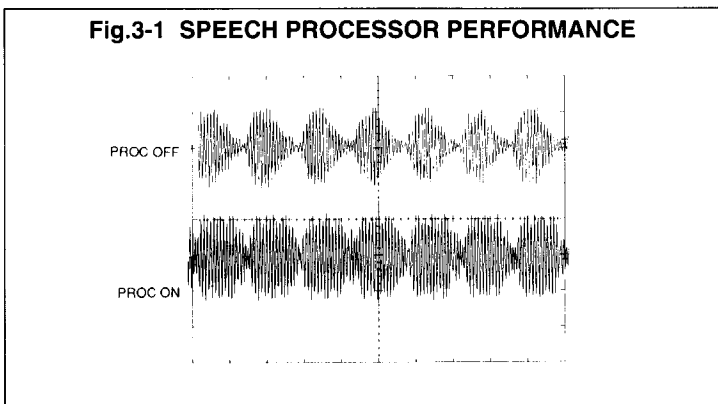
The Collins<sup>®</sup> Mechanical Filter in the 455 kHz IF provides a very flat passband, with negligible ripple which might distort the voice reproduction. Other analog filtering circuits during the transmit signal path ensure a clean signal at RF.

### (C) RF Speech Processor

The SSB speech processor is the so-called "RF Clipping" type. During processor operation, the 455 kHz IF signal is compressed via a limiter IC which filters this signal with a low-Q Low-Pass Filter, then mixes the signal to 8.215 MHz where the signal passes through an eight-pole crystal filter and is then amplified. The result is increased "talk power," on an order of magnitude of 6 dB or better.

The RF Speech Processor design is superior to other types, because it provides lower distortion along with a higher increase in talk power. As with all such designs, of course, the drive levels must be carefully adjusted; fortunately, the extensive metering capability of the FT-1000MP makes level adjustment quick and fool-proof.

The combination of the RF Speech Processor, front-panel carrier point adjustment, and the EDSP Microphone Equalizer provide the operator with extensive ability to tailor the response and compression level of the transmitter to his or her voice pattern. This means that less power is wasted in the production of unneeded areas of the modulation envelope, and consequently more available power can be concentrated in the useful frequency components of the operator's voice.

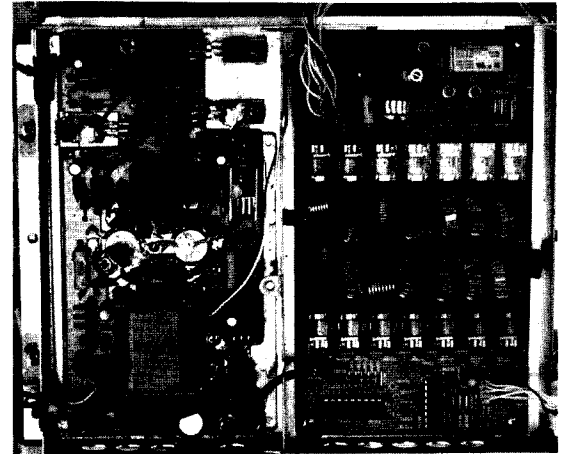


### (D) RF Power Amplifier

The push-pull final amplifier stage utilizes bipolar 2SC2879 transistors, which proved to be so reliable in the 200-watt power amplifier for the FT-1000D. At the 100-watt power level, this amplifier design is extremely stable and provides excellent linearity.

The Duct-Flow Cooling System (DFCS) combines a large cross-flow cooling fan and heat sink to provide excellent dissipation of heat generated in the power supply and power amplifier areas. The entire chassis design is formulated around efficient heat transfer and dissipation from the rear, side, and front panels, thus simplifying the routing of cables (since heat buildup is not allowed to occur in any one area).

The operation of the cooling fan is thermostatically controlled by heat sensors in both the power supply and the power amplifier.



● RF POWER AMP + LOW PASS FILTER CIRCUITS

### (E) Automatic Antenna Tuner

Using its own 8-bit Central Processing Unit (CPU) for tuner control, the Automatic Antenna Tuner command and control circuitry chooses re-selected fixed inductor values, and drives a variable capacitor, to achieve optimum impedance matching.

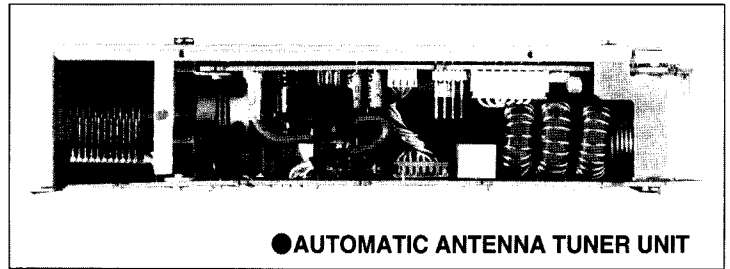
The Auto Tuner is equipped with a preset memory for each amateur band, plus general-purpose preset memories for any arbitrary band, yielding a total of 31 of available presets for the antenna tuner. Memory data can be stored every 10.24 kHz, if needed, so as to allow efficient movement around a band once tuner memory data is stored. In any event, eight memories are reserved for a "preset" function, one per band other than the currently-used band, so as to serve as a starting point for operation whenever a band change occurs.

The control circuitry is "smart," in that it anticipates transmission requirements as you move around a band, presetting itself to (A) the impedance-matching data already stored in memory, or (B) the predicted impedance requirements based on your last-used frequency and the direction/magnitude of frequency excursion. In the latter case, although no such "estimate" can be entirely accurate, the presetting dramatically reduces any needed retuning time when transmission eventually occurs.

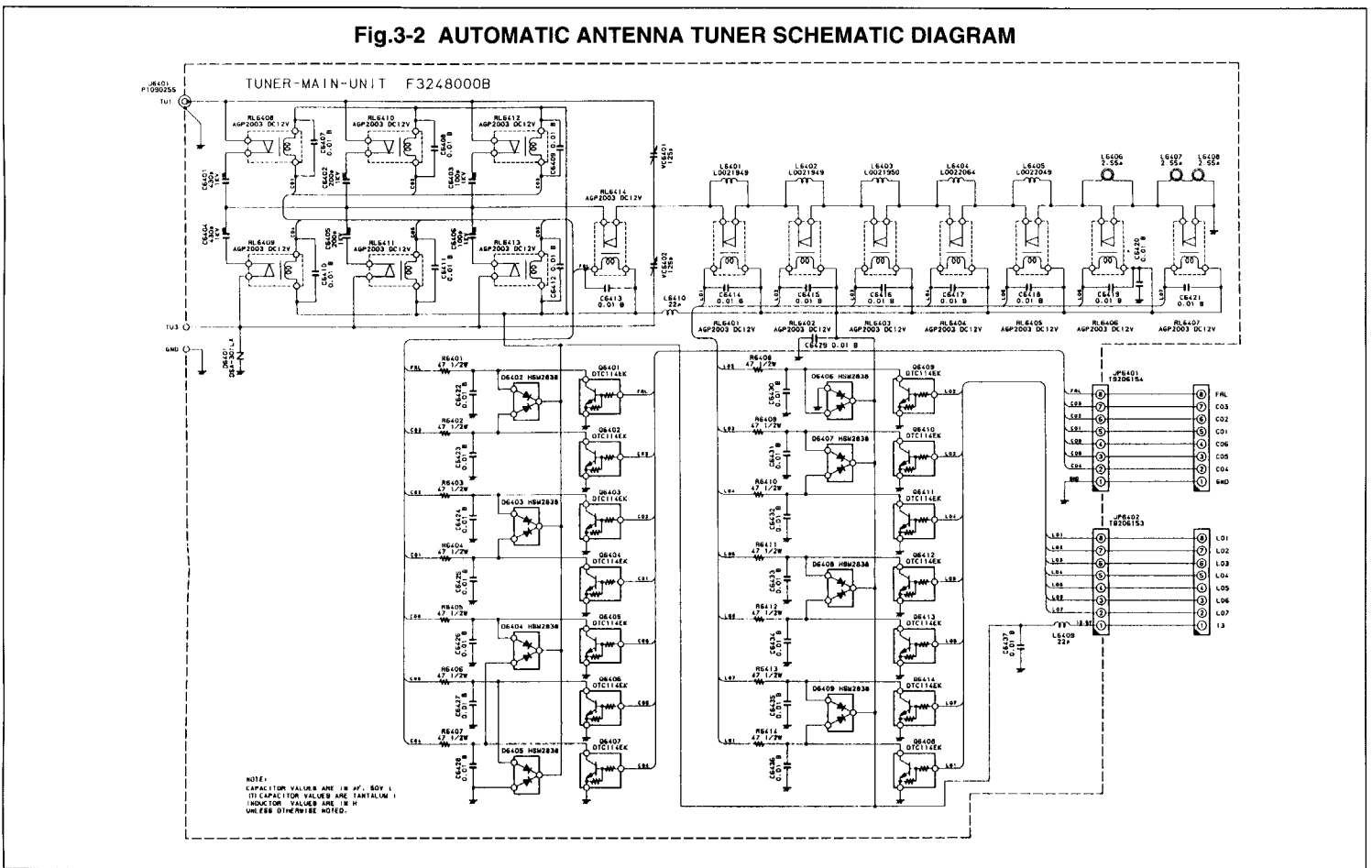
Extremely fast tuning speeds are possible, thanks to the geared tuning motor and detailed impedance data provided by the LPF (Low-Pass Filter) Unit's directional coupler. The tuning circuits have been designed using high values of capacitance, so as to minimize losses through coils, and the high resolution and electric braking on the variable capacitor motor yield imperceptible overshoot or undershoot in the tuning alignment.

The antenna tuner also can sense and report a catastrophic antenna failure or erroneous antenna selection (e.g. the operator mistakenly attempts to use a 40-meter Yagi on 20 meters), and will suspend antenna tuning in such instances.

Ideal for smoothing out impedance variations across an entire amateur band, the Automatic Antenna Tuner in the FT-1000MP is the fastest, most sophisticated total design package ever incorporated in an Auto-Tuner in an amateur radio transceiver to date.



**Fig.3-2 AUTOMATIC ANTENNA TUNER SCHEMATIC DIAGRAM**



## 4. Local Oscillator Design Features

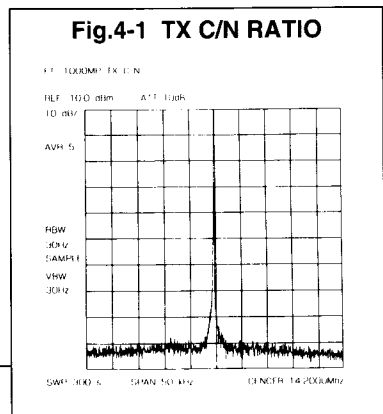
### (A) Single-Crystal-Reference Main Oscillator System

With all the attention given to establishing and maintaining high Signal-to-Noise ratio in the FT-1000MP, as described earlier, it is clear that the local oscillator structure of the transceiver must be extraordinarily clean, as any noise-generating deficiencies will be quickly noticed by the operator. Moreover, with so many interference-fighting circuits in use, the possibility of spurious beats between oscillators is a significant challenge to engineers. To conquer these potential adversities, Yaesu's engineers incorporated a unique single-loop PLL structure, utilizing a high-stability master reference oscillator and low-noise, high-resolution Direct Digital Synthesizer (DDS).

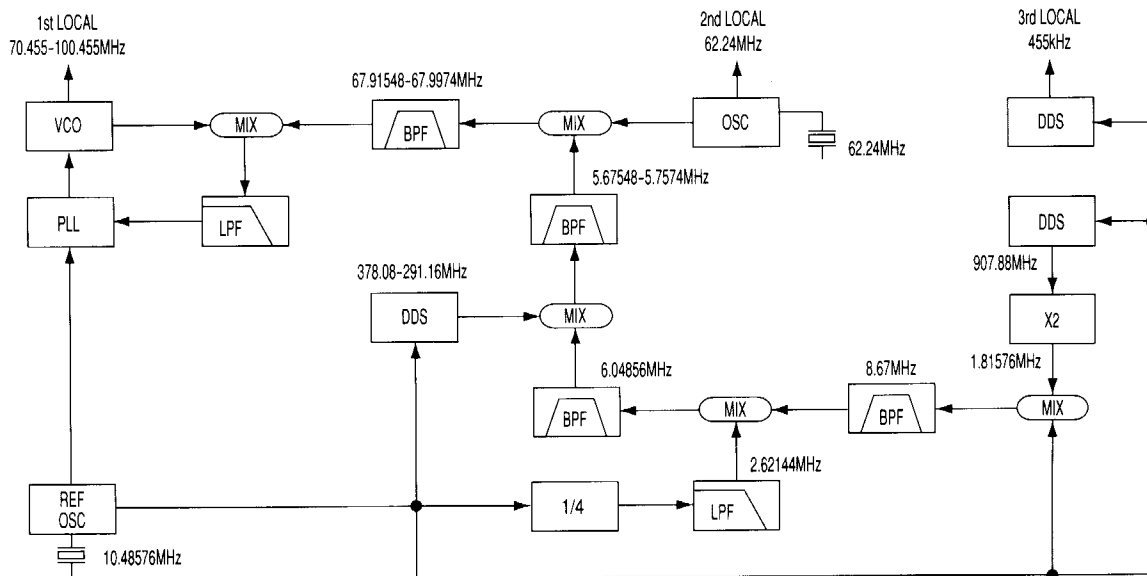
This method has produced a local oscillator structure which provides exceptionally fast lock-up time, high Carrier-to-Noise (C/N) ratio (for both the VCO and the new local oscillator output), and outstanding frequency resolution. Yaesu's engineers optimized the design around the often-conflicting objectives of (A) reducing phase noise from strong signals separated 20~50 kHz or more from the desired signal, (B) reducing phase noise from close-in

signals (separated by 1 kHz or less), (C) reducing the magnitude of discrete spurious signals (as opposed to broadband noise), (D) reducing synthesizer noise on the high bands, where noise figure is critical, and (E) reducing synthesizer noise on the low bands, where noise figure is not so critical but where high signal levels can cause serious synthesizer-noise problems.

The result is an oscillator system which will sustain the input from a broadband front end amplification system, does not fill a 250 Hz or 500 Hz low-noise bandwidth with rushing noise from a CW carrier, and yet one which provides transmit / receive turnaround times fast enough for the most demanding data applications.



**Fig.4-2 (1) LOCAL OSCILLATOR BLOCK DIAGRAM**



**Fig.4-2 (2) SUB RECEIVER LOCAL OSCILLATOR BLOCK DIAGRAM**

