Product Review

ICOM IC-701 HF Transceiver

It seems as though everyone and his brother is introducing a new hf transceiver to the amateur market these days. Each is purportedly bigger and better than the competition's, performing all sorts of marvelous deeds with the exception of tying your shoelaces. With 128 transistors, 23 FETs, 56 ICs and 265 diodes, the INOUE Communications IC-701 is proof that good things can come in small packages.

The transceiver measures a mere 4-3/8 inches high × 9-1/2 inches wide × 12-1/4 inches deep (111 × 241 × 311 mm). When placed next to the competition's equipment, the IC-701 occupies considerably less space. With the matching IC-701PS ac-operated power supply, which measures 4-3/8 × 7 × 10-1/4 inches (111 × 178 × 260 mm), beside the transceiver they take up approximately the same amount of room as other transceivers alone. The power supply is connected to the back of the transceiver through a heavy-duty, yet flexible, six-foot umbilical cord so it's possible to stow the power supply away from the operating position. However, the power supply is styled to match the transceiver and contains an external 3- × 5-inch (76 × 127 mm) speaker, so if there's room at the operating position it might as well stay. For the record, the transceiver also has a built-in speaker, should it be used without the '701PS power supply.

The '701 is what you would expect from a transceiver employing space-age technology. With the optional RM-2 computer hookup, one can program the transceiver to scan an entire band, a portion of a band and even automatically switch bands and tune to specific frequencies! To incorporate remote band switching, the ICOM engineers have used a multisection, motorized rotary switch. Changing the position of the band switch results in a series of clicks as the rotary switch steps its way to the selected band.

The only option available for the '701 is the RM-2 computer. Items normally found as options on other radios are standard equipment on the '701. For example, standard equipment includes digital readout, wide and narrow cw bandwidths, a cooling fan, rf speech processor, band-pass tuning, noise blanker, dual-speed tuning dial, narrow and wide shift RTTY, VSWR indicator and a built-in second VFO. A single tuning knob controls each VFO independently with a front-panel switch selecting one of the following modes: transceive on VFO A; transceive on VFO B; receive on A, transmit on B; and receive on B, transmit on A. The package also includes a neatly styled Electret condenser microphone with built-in preamplifier. Dc voltage is fed to the preamplifier through the four-conductor microphone cable. There are *no* batteries to replace.

Technical Specifics

A block diagram of the IC-701 appears elsewhere in this review. The '701 employs a digital phase-locked-loop (PLL) circuit as the local oscillator for both transmit and receive. Output from the PLL is 9.0115 MHz higher than the frequency of operation (the i-f is 9.0115 MHz). The PLL frequency is determined as follows. A pulse generated by the optical chopper circuit, located at the tuning knob, is digitalized by the up/down counter in the large-scale integrated circuit (LSI) and used to control a programmable divider, also located inside the LSI chip. The programmable divider controls the PLL circuit which determines the frequency of the voltage controlled oscillator (VCO). A front-panel switch is used to select the synthesizer tuning rate at either 100-Hz or 10-kHz steps.

Receiver

Signals arriving at the antenna connector pass through the transmitter low-pass filter and an attenuator (0 or 10 dB) and are then diode-switched to one of the six individually optimized MOSFET rf amplifiers. From there, the signals are applied to a Schottky-diode, doubly balanced mixer where they are mixed with the local-oscillator signal from the VCO. The resultant i-f is at 9.0115 MHz and the signals are passed through a 10-kHz wide monolithic filter. The output from the filter is then passed through the noise-blanker gate to a second 9.0115-MHz filter with a bandwidth of 2.4 kHz. From there, the signal is amplified and routed to the band-pass tuning circuitry.

Basically, the band-pass tuning system consists of two SN76514 mixers with an additional filter located between them. The center frequency of this filter is 10.75 MHz and is 2.4 kHz wide. A variable-crystal oscillator (VXO) circuit provides identical injection information for both mixers at about 19.7615 MHz. This injection up-converts the existing i-f at 9.0115 MHz to the new 10.75-MHz i-f where the signal passes through the 10.75-MHz filter. Output from the filter is immediately down-converted to the previous i-f of 9.0115 MHz. Since the down-conversion is equal to the up-conversion (the oscillator being used for both), changing the VXO frequency does not change the frequency of the received signal. The output frequency is always equal to the input frequency; the VXO only changes the position of the signal in the 10.75-MHz filter passband.

Output from the band-pass tuning circuit is amplified in the i-f stages and applied to the product detector. For narrow cw operation, the signal is routed through an active audio filter, through a low-level af amplifier, low-pass filter and finally to the audio output stage. For wide cw operation, the active audio filter is bypassed.

A combination of i-f and audio-derived age systems is used in the '701. Age characteristics are switchable with a front-panel control, with FAST for cw operation and SLOW for phone work. The SLOW system features a hang-age characteristic.

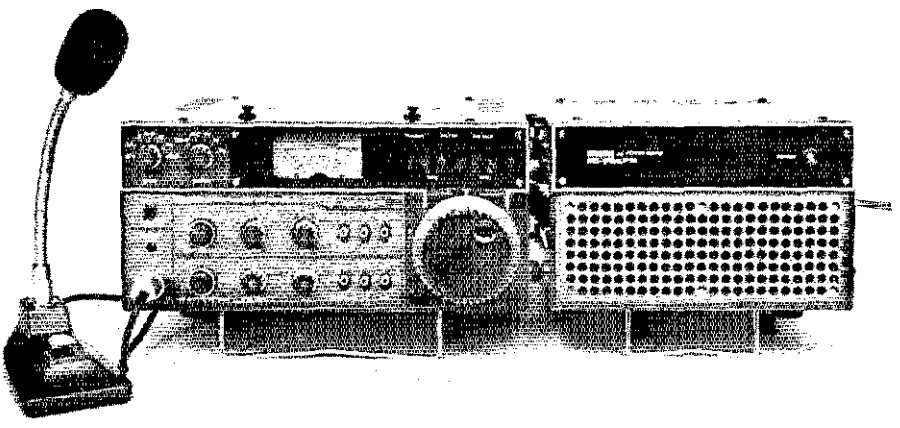
Receiver-performance tests as outlined by Hayward[1] were performed on the '701 and yielded the following numbers: noise floor, −133 dBm; blocking dynamic range, in excess of 120 dB (beyond limit of measuring equipment); and IMD dynamic range, 87 dB. These tests were performed at 14 MHz. An additional set of tests was run at 3.5 MHz where the numbers turned out to be identical except for the IMD dynamic range which increased to 89 dB.

Transmitter

The IC-701 transmitter circuitry is quite straightforward, as outlined in the block diagram. A detailed circuit analysis will not be given here. Simply, a double-sideband signal is generated at the 9.0115-MHz i-f and passes through the 9.0115-MHz filter where it becomes a single-sideband signal. From there it passes through a buffer stage to the transmit mixer. Here the signal is combined with the VCO to produce an output signal at the desired frequency of operation. Finally, the signal is applied to an amplifier and buffer, and then to

[1]Hayward, "Defining and Measuring Receiver Dynamic Range," July 1975 *QST*.

The ICOM IC-701, shown here with matching power supply/speaker unit. The '701 itself is the same size as the IC-211, and in fact looks practically identical to the 2-meter rig.



IC-701 BLOCK DIAGRAM

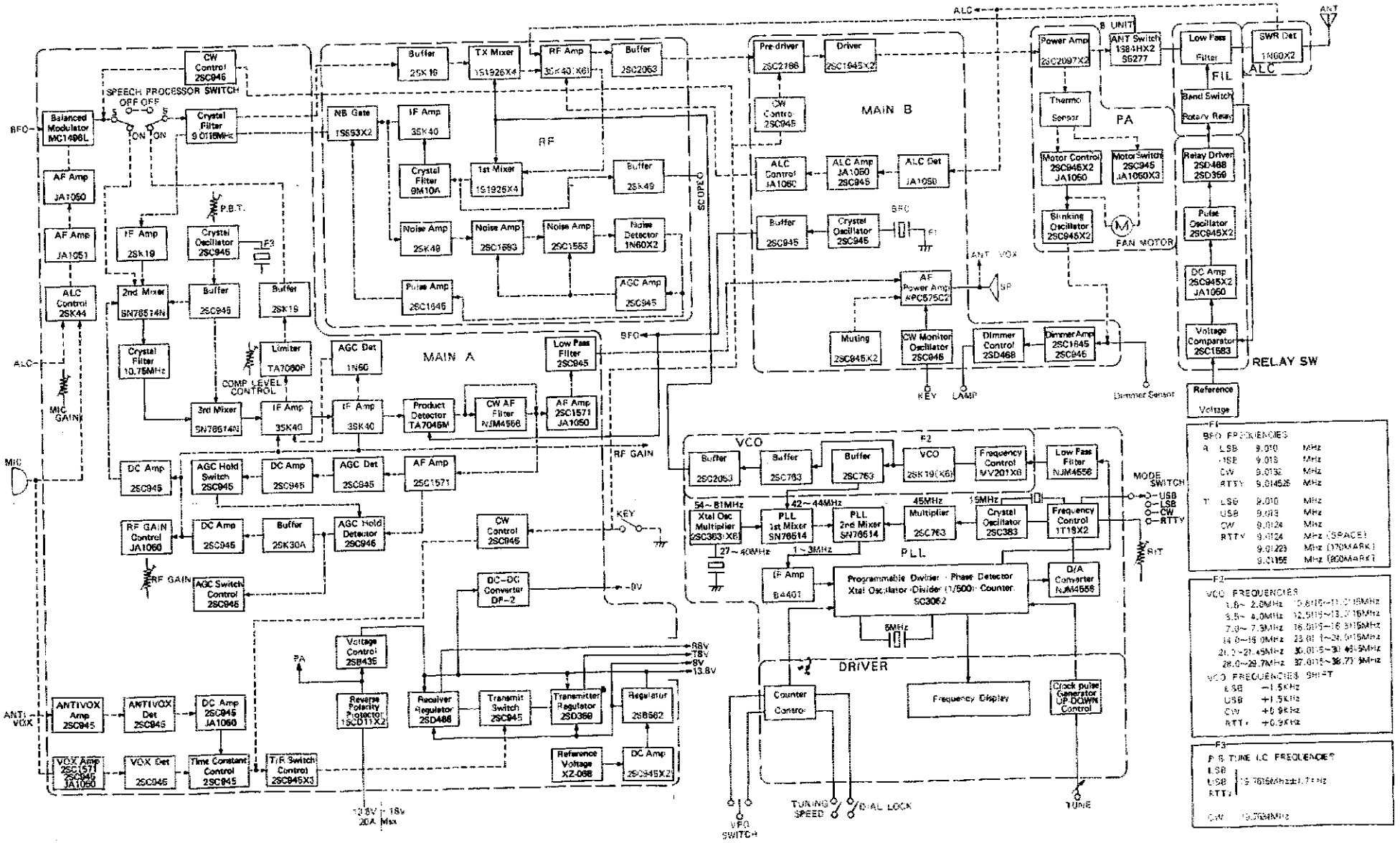


Fig. 1 — Block diagram of the IC-701, as shown in the owner's manual.

the predriver, driver and final-amplifier stages. Cw operation is accomplished by unbalancing the balanced modulator.

Rf speech processing is performed at the 10.75-MHz i-f and is of the rf-compression variety. With the processor switched on, the 10.75-MHz filter serves to eliminate the undesired sideband and the 9.0115-MHz filter is used to clean up the processed rf signal.

The predriver, driver and final-amplifier stages are broadband, which means that no transmitter tuning is necessary. All one does is select the frequency of operation and adjust the microphone- or cw-level control, and that's it. Needless to say, band switching is a snap. The transmitter has an SWR shut-down protection circuit, so if the load connected to the transmitter is significantly different than 50 ohms, the transmitter will automatically lower the output power in order to protect the final-amplifier devices. The transmitter has no difficulty working into various mismatches up to a 3 to 1 SWR while supplying full transmitter power. Spectrum-analyzer photographs of the transmitted signal are shown elsewhere in this review.

Operation

"Silky smooth" perhaps best describes the operation of the '701. Each knob and switch seems as though it has been independently engineered for the perfect "feel" — just what you'd expect from a radio in this price class! Transfer from receive to transmit is extremely quiet with none of the usual loud clicks or thumps. The same is true when changing bands or modes or when operating any of the six front-panel toggle switches.

The RIT push switch is of the latching type, so it must be pressed once to turn the RIT on and one again to turn it off. When the RIT circuit is on, it is automatically pulsed off if the main-tuning knob is turned! Should you not desire this luxury, a simple modification can be made which involves changing a lead from one post to another.

The large-scale meter can be used to monitor collector voltage, collector current, relative power output, rf speech-compression level, and SWR on the line. The noise blanker was found to be quite effective in reducing automobile ignition noise and helpful on certain types of line noise.

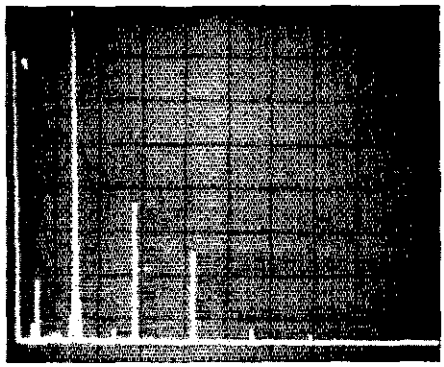
A thermostatically controlled cooling fan is another interesting feature of the '701. Should the final transistors need additional cooling, as they might during a very long transmission, the fan comes on automatically. It is extremely quiet, making it difficult to tell whether or not the fan is in operation. If the temperature of the final transistors should ever reach the danger point, the fan will switch to a higher speed and the frequency display will begin to flash on and off! The fan seldom came on during normal operation but energized a bit more frequently during "contest style" operation.

Inside the small "trap door" on top of the transceiver are located controls or switches for the following: display bright/dim, RTTY wide/narrow, SWR forward/reverse switch and sensitivity control, cw monitor level, frequency set, VOX gain, antiVOX, cw VOX delay, and ssb VOX delay.

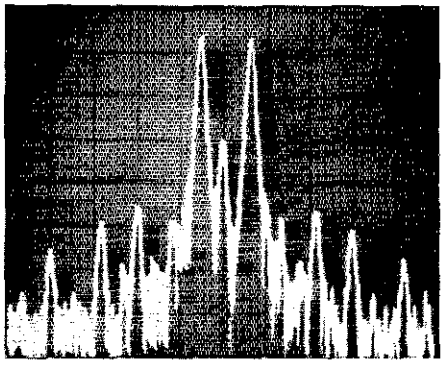
The two most commonly asked questions about the IC-701 have been, "How's the receiver hold up under strong signals?" and "What's it like tuning the bands in 100-Hz steps?" Well, laboratory tests are fine, but, there's no better test for a receiver than to hook it to a moderately sized antenna at a hilltop location in central Connecticut (or any other congested rf environment) during a contest weekend! So we did just that. With at least nine or 10 line-of-sight stations all operating with the maximum legal power and gain antennas (the closest was less than 1-1/2 miles away), no IMD products were noted when tuning the various bands. A slight amount of desensitization occurred when operating within 10 kHz or so of the station located 1-1/2 miles away. This impaired reception of only the weakest of signals and was not considered particularly objectionable. All in all, the receiver performed exceptionally well.

As for the tuning rate, it did take a few hours to get used to tuning the band in 100-Hz increments. There were no instances when an ssb or cw signal couldn't be tuned in to sound "just right." After a week of operation the step tuning was barely noticeable. There are two step rates with which the receiver can be tuned — 100 Hz and 10 kHz. In the 100-Hz position, one revolution of the tuning dial corresponds to a 5-kHz frequency change. In the 10-kHz position one revolution is 500 kHz. The faster rate position would be used for a quick QSY from one part of the band to another.

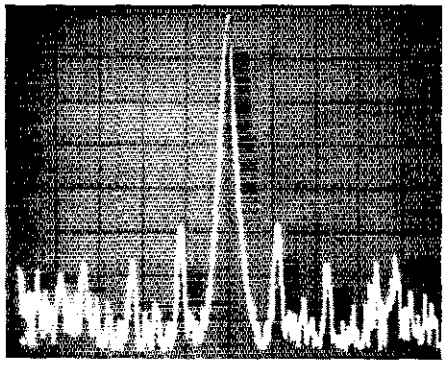
There were two minor sore points that we



Here is a spectrum analyzer photograph of the worst case for spectral purity; the transmitter is operated at the full input power. The vertical scale is 10 dB/division and the horizontal display is 10 MHz per division. The second harmonic can be seen at 45 dB below the carrier and the third harmonic is at 54 dB below the carrier.



In this photograph is the display of a two-tone IMD test as performed on the IC-701 running at the full rated input power level. The horizontal display is set for 1 kHz/division and the vertical scale corresponds to 10 dB per division. As can be seen, the third-order IMD products are down a remarkable 45 dB as referenced to the PEP output. The fifth order products are down roughly 49 dB.



This photograph is of the IC-701 transmitted signal on 14 MHz. Each horizontal division corresponds to 100 Hz and each vertical division is equal to 10 dB. The two large pips on either side of the carrier are 120-Hz hum, the level of which is 48-dB down from the main signal. The purpose of this photograph is to show the purity of the synthesized signal.

ICOM IC-701 HF Transceiver Specifications

Frequency Coverage:	1.8-2.0 MHz 3.5-4.0 MHz 7.0-7.5 MHz 14.0-15.2 MHz 21.0-21.5 MHz 28.0-30.0 MHz

Transmitter

Dc input power: Ssb (A3j) 200 W, cw (A1) 200 W.
Emission modes: Ssb (A3j), cw (A1) and RTTY (F1).
Harmonic output: More than 40 dB below peak power output.
Spurious output: More than 60 dB below peak power output.
Carrier suppression: More than 40 dB below peak power output.
Unwanted sideband: More than 40 dB down at 1000 Hz af input.
Frequency stability: Less than 500 Hz change after switch on 1 minute to 60 minutes, and less than 100-Hz change after 1 hour. Less than 1-kHz change over the temperature range of −10°C to +60°C.
Power supply requirements: Dc 13.6 V ±15 percent at 18 A maximum.
Antenna impedance: 50 ohms unbalanced.

Receiver

Receiving modes: Ssb (A3j), cw (A1) and RTTY (F1).

Sensitivity:	Ssb, RTTY	2.4 kHz at −6 dB (adjustable to 1 kHz min.) 4.0 kHz at −60 dB
	Cw	0.5 kHz at −6 dB 1.4 kHz at −60 dB
	Cw narrow	0.2 kHz at −6 dB 1.0 kHz at −60 dB.

Spurious response rejection: More than 60 dB.
Audio output: More than 1.5 W.
Audio output impedance: 8 ohms.
Price class: $1600.
Supplier: ICOM East, 3331 Towerwood Dr., no. 307, Dallas, TX 75234.

noted, the first being that the received audio on extremely loud signals could sound mildly distorted when using the fast age. Use of the slow age completely cured the problem. The second sore point was that of keying the transmitter. In order to properly operate the transmitter, the keyer must bring the key terminal to within 0.4 volt of ground. At least two keyers we tried would not key the transmitter. A simple cure for those keyers would be to use a relay between the keyer and the transmitter or, as we did, connect a 1-1/2-volt battery in series with the keyer output in reverse-bias fashion. This brings the key-down voltage to the negative side of zero volts. — *Jay Rusgrove, W1VD*

INFO-TECH MODEL 300 KEYBOARD

Recently joining the solid-state cw/RTTY keyboards now available, the Info-Tech model 300 offers all commonly used RTTY speeds (60, 66, 75 and 100 wpm), cw speed variable in 1-wpm increments from four to 125 wpm, a 700-character running buffer, 11 separate storage memories, an RTTY loop output, and a built-in afsk generator. The model 300 also has 110- and 300-baud ASCII. At the time of this writing, amateur use of ASCII is limited to OSCAR.

At first glance, the model 300 looks very simple — there isn't a single knob on the front panel! But commands are given by pressing the keys in various sequences. For example, after the three-wire line cord is plugged in and the power switch turned on, the "Morse" (cw) mode is selected by pressing the CONTROL and M keys simultaneously, entering the speed desired (as a numeral corresponding to the number of words per minute), and finally hitting the RETURN key. The cw weight ratio is variable in nine steps. The setting of the weight does affect the speed somewhat; the entered speed is correct only when the dit-to-space ratio is 1:1. All nine settings of the weight ratio are reasonable, in contrast to some keying devices with which a sizable portion of the control range results in ridiculous extremes.

A CQ key and a DE key are provided. For some reason, no word space is programmed into these functions following the characters, so if you hastily press the CQ and DE keys followed by WQ1XYZ, you'll hear it come out as "CQDEWQ1XYZ." The word-space bar must be used to insert the necessary spaces with these functions. For ragchewing, words can be "burst" typed one at a time, pausing for word spaces, or you can get way ahead of the output by using the buffer and separating words by means of the word-space bar.

The cw prosigns $\overline{AR}$, $\overline{AS}$, $\overline{BT}$ and $\overline{SK}$ are sent by shifting certain characters. All standard punctuation is also provided. There's a cw sidetone with adjustable volume built into the keyboard. A monitor output and auxiliary input are provided. The transmitter may be keyed through a remote PTT line.

One rather strange problem was encountered with the unit we tested. Although the cw keying output is handled by a relay rated at 200 V dc or 500 mA with a power limitation of 10 W, we couldn't get the model 300 to key either the Kenwood TS-820S or the Collins 32S-3. No matter what we tried to send, the keyboard produced only an erratic series of dits when connected to a transmitter. We tried only these two rigs, but neither of them offer a challenge to the keying-relay ratings. We informed Info-Tech of this difficulty and returned the keyboard to them. The problem was corrected by means of a three-conductor jack installed at the cw output instead of the original two-conductor jack. The two inner contacts are used for the keying circuit, isolating the relay contacts from the keyboard chassis. No further keying anomalies took place.

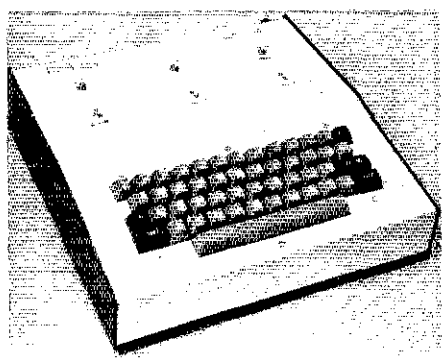
RTTY operating conveniences include a RETURN key which actuates the signals for carriage return, line feed, and the case of the character sent just before the RETURN key is pressed (either FIGS or LTRS), in that order. At the end of a 71-character line, the RETURN function is automatically triggered. There are no keys labeled FIGS or LTRS; case shifting is done automatically. However, FIGS and LTRS signals can be generated by shifting the period and comma. An RY test signal and a "quick brown fox" test key are provided. There's also an automatic cw identifier. An "RA monitor" output is provided for monitoring RTTY or ASCII transmissions with the receiving terminal unit.

The afsk feature makes RTTY transmission possible with any ssb transmitter or transceiver; the tones are simply fed to the microphone input in the lsb mode and the result is (theoretically) F1 emission. The afsk generator in the model 300 uses standard "high tones" (2125 and 2295 Hz for narrow shift and 2125 and 2975 Hz for wide shift). The audio output is 2.5 volts peak-to-peak, and if the tones are fed into the microphone jack, attenuation is usually necessary to prevent overloading the transmitter audio stages. The single-tone distortion of the afsk output was measured as 2 percent by means of an audio distortion analyzer.

The reason we say "theoretically" in the previous paragraph when referring to F1 emission is that the slightest stray noise will show up on the air along with the RTTY signal when F1 emission is sought in this way. The model 300 was tested with a popular hf ssb transceiver in the ARRL lab to see how clean the "F1" emission really would be. The result is shown in the spectral photograph of Fig. 1.

The memory capability of the model 300 is considerable. Errors can be corrected in the running buffer or storage memories anytime prior to their actual transmission. There are 11 storage memories, each 120 characters in length. If a message runs out of room while being programmed into a given memory, the overflow will be taken up by the next memory. Messages can be "nested," meaning that one message can end by calling another message from any of the storage memories. A separate identification memory is supplied. These memory features are identical for "Morse," RTTY and ASCII.

The instructions give installation and operation procedures, alignment information for the afsk generator and RTTY identifier, and details for changing the cw sidetone pitch. There is a brief circuit description with a schematic diagram. An errata sheet (including



The Info-Tech model 300 RTTY/ASCII/cw keyboard. The control functions are all executed by pressing the keys in specific sequences. The small black protuberance at the extreme upper right (rear panel) is part of the fuse holder. The only rotatable adjustment control is the cw sidetone volume pot, located on the rear apron.

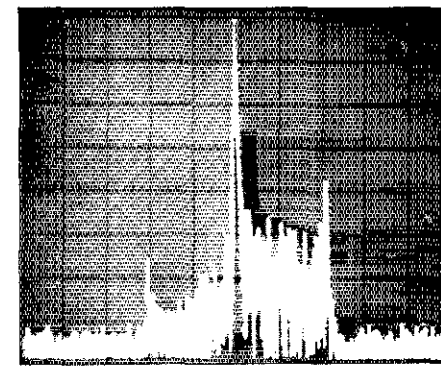


Fig. 1 — Spectral photo of TS-820S output on 3595 kHz lsb, with 2125-Hz single-tone input from the model 300. Each horizontal division represents 1 kHz and each vertical division represents 10 dB. The pip farthest to the right is the transmitter suppressed-carrier frequency. The center (tallest) pip is the signal resulting from the 2125-Hz tone. The pip at the left is the signal resulting from the second harmonic of the 2125-Hz tone. The transmitter power input was approximately 90 watts.

Info-Tech Model 300 Keyboard

Dimensions (HWD): 3-7/8 × 12-3/4 × 13 inches (98 × 324 × 330 mm).
Weight: 7.1 pounds (3.2 kg).
Power requirements: 110-120 V ac, 50-60 Hz, 12 W maximum.
Cw speed range: 4-125 wpm in 1-wpm increments.
Cw keying output: +200 V dc or 500 mA, 10-W maximum contact rating.
Cw monitor output: +20 V dc maximum off state, 50 mA maximum on state.
Cw auxiliary input: +5 V dc off state, 0.5 mA on state.
Sidetone audio: Approximately 1/2 W to internal speaker.
RTTY speeds: 60, 66, 75 and 100 wpm (Baudot code).
ASCII speeds: 110 and 300 baud.
Loop (fsk) output: nonisolated, open-collector; 200 V dc maximum off state, 100 mA maximum on state.
RA monitor output: at least +4 V dc marking, less than +0.3 V dc spacing, high impedance.
RTTY/ASCII afsk output: 2.5 V pk-pk, 1000 ohms impedance; 2125 Hz mark, 2295 Hz (space for narrow shift), 2975 Hz (space for wide shift).
Remote PTT output: +200 V dc and 100 mA maximum.
Buffer memory: 700 characters.
Storage memory: 11 addressable memories, 120 characters each; 1320 characters total.
Supplier: Info-Tech, Inc., 2349 Weldon Parkway, St. Louis, MO 63141.
Price class: $450.