calibration factor. The peaks at 1000 MHz, 1010 MHz, and 1030 MHz are from TACAN and interrogator beacons. The responses around 1090 MHz represent interrogator beacon replies.

ARSR-lE (Fig. 8). The spectrum shown here was selected from among the worst of the filtered amplitron ARSR-lE spectra that were measured. Figure 8b shows more detail in the middle 20 MHz of spectrum; note the decrease in measured amplitude caused by the more narrow 300 kHz measurement bandwidth.

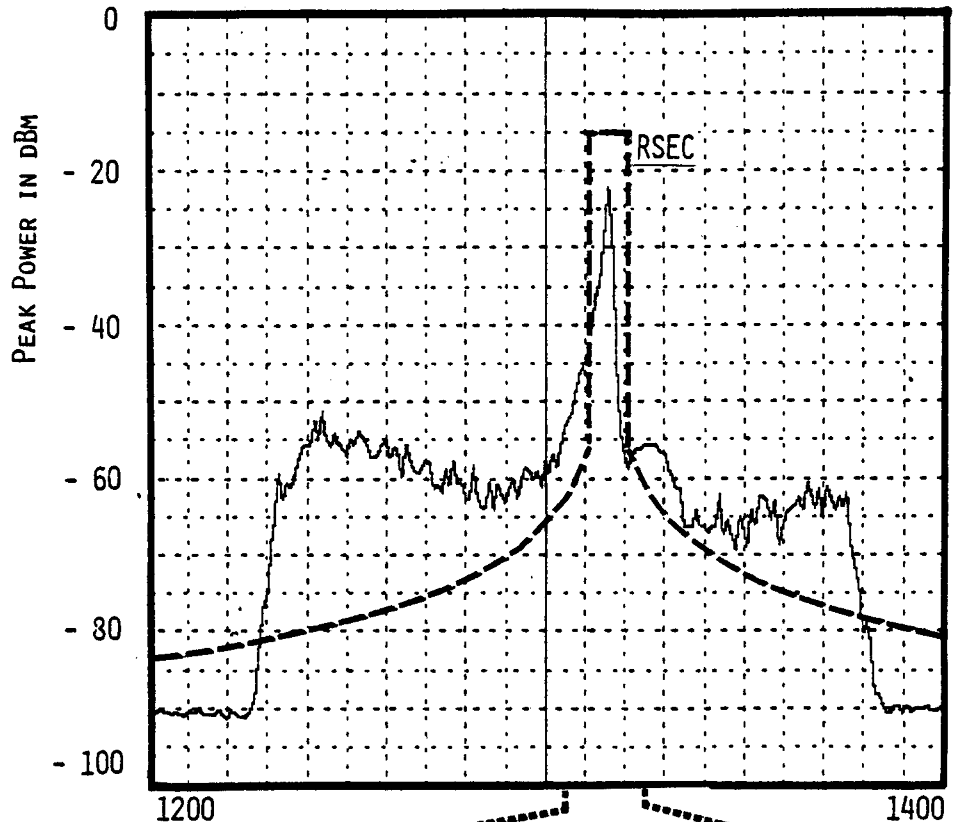
FPS-107 (Fig. 9a). The FPS-107 is a two dimensional L-band long-range search radar designed for ground-controlled-intercept (GCI) applications in the air defense system. The FPS-107 uses a klystron, providing 10 MW peak power, and a 481 kilometer (260 nmi) range. The klystron, as illustrated here, is an impressive example of spectrum conservation.

ARSR-3 (Fig. 9b). The ARSR-3 is a two dimensional L-band air-route-surveillance radar with a detection range of 444 kilometers (240 nmi)--when operating in the diplex mode. Its klystron output provides 5 MW peak power with 3.3 kW average power. The radar can be operated in a non-stagger or stagger mode with 5, 7, or 8 discrete periods about the selected average PRR. When measured, the radar was still in a developmental stage and only one channel was operational.

6. SPECTRA OF HEIGHT-FINDING RADARS

All of the radars in this section are long-range, high-power, air-transportable, height-finders with a maximum range near 370 kilometers (200 nmi) and a height-finding capability of about 22,500 m (75,000 ft). They are normally collocated with an L-band search radar of comparable range--an ARSR-lE, for example. The height-finding radars operate in the 2700-2900" MHz band and in many areas contribute substantially to the spectrum crowding in this band. The older height-finders used conventional magnetrons, but many are being equipped with newer coaxial magnetrons whenever a major overhaul is scheduled. Several examples of conventional and coaxial magnetron radars are included in this section for comparison. The RSMS has been used to measure radar spectra for both types of output tube and in one case was able to measure the same radar both before and after it was converted from conventional to coaxial magnetron. The before-and-after measurements were made on an FPS-90, and care was taken to ensure that all measurement parameters were the same for each example including the measurement site location of the RSMS. Figure 10a shows the conventional magnetron radar spectrum, and figure 12a shows the coaxial magnetron spectrum for comparison. The conventional magnetron clearly displays the characteristic “porch” just prior to

a. ARSR-1E, Amplitron (1000 kHz measurement bandwidth), waveguide filtered.



b. ARSR-1E, Amplitron (300 kHz measurement bandwidth).

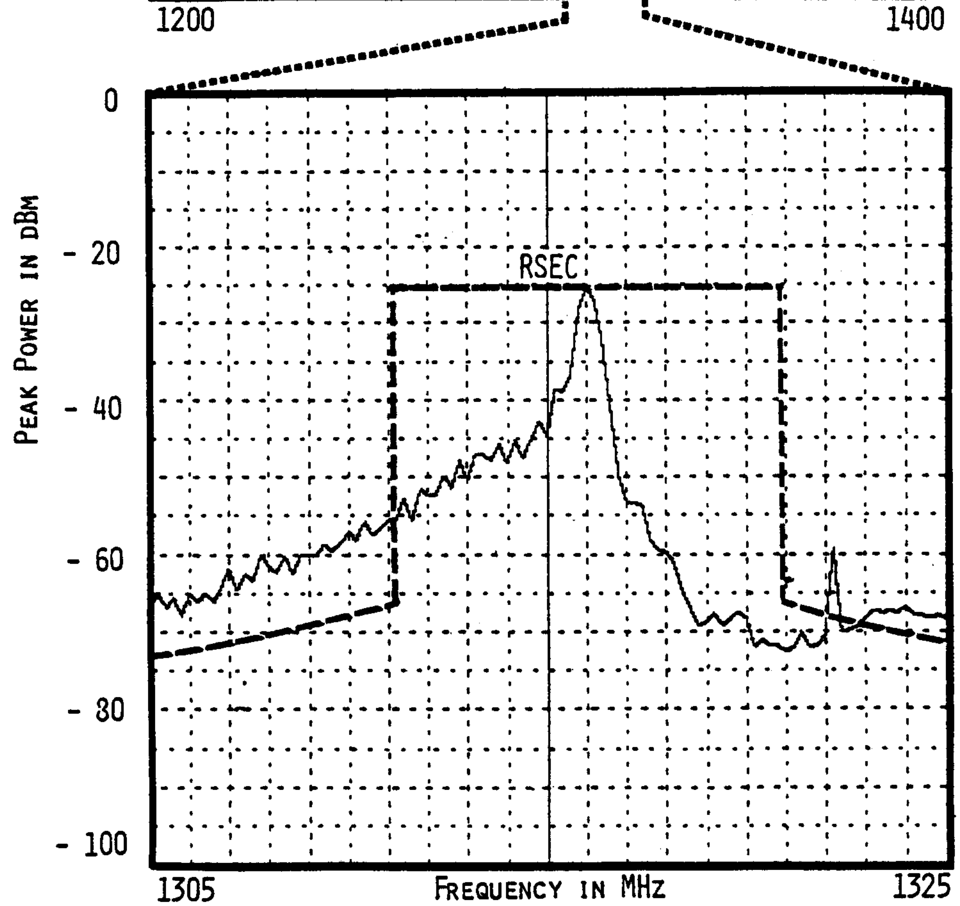
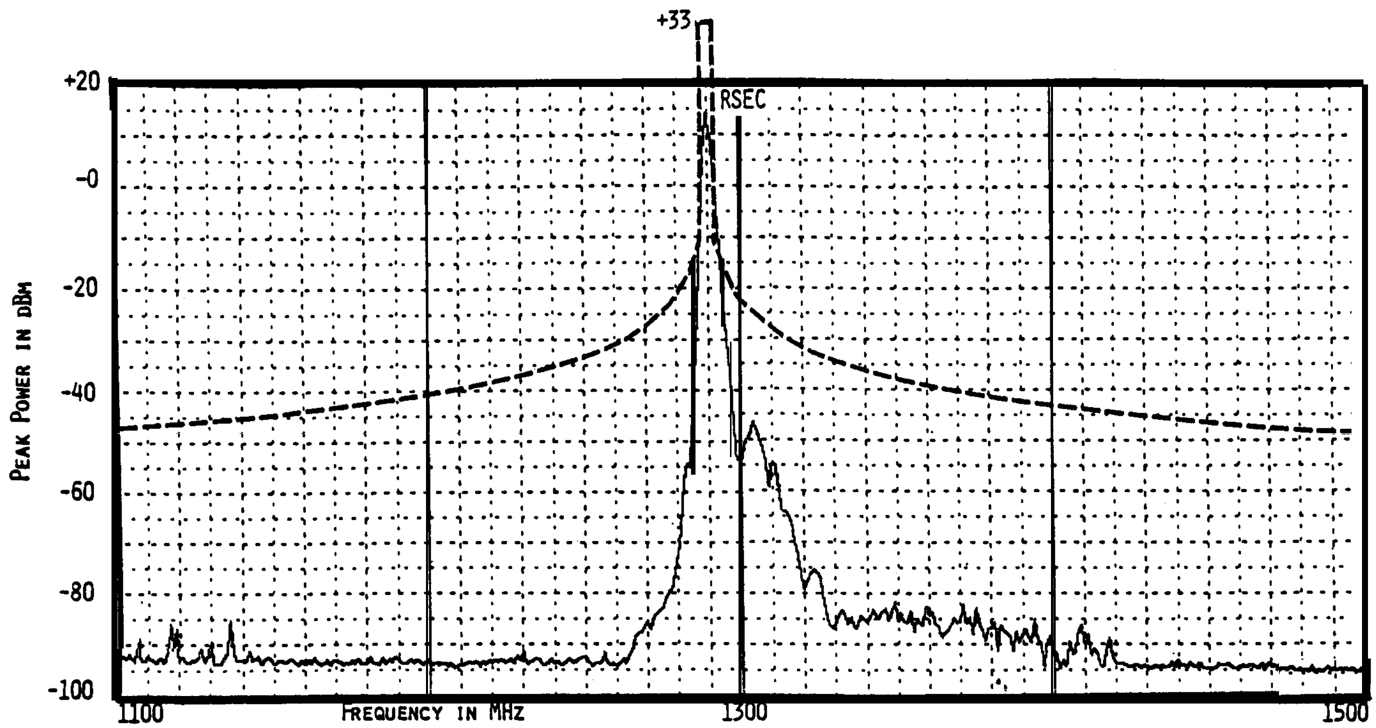
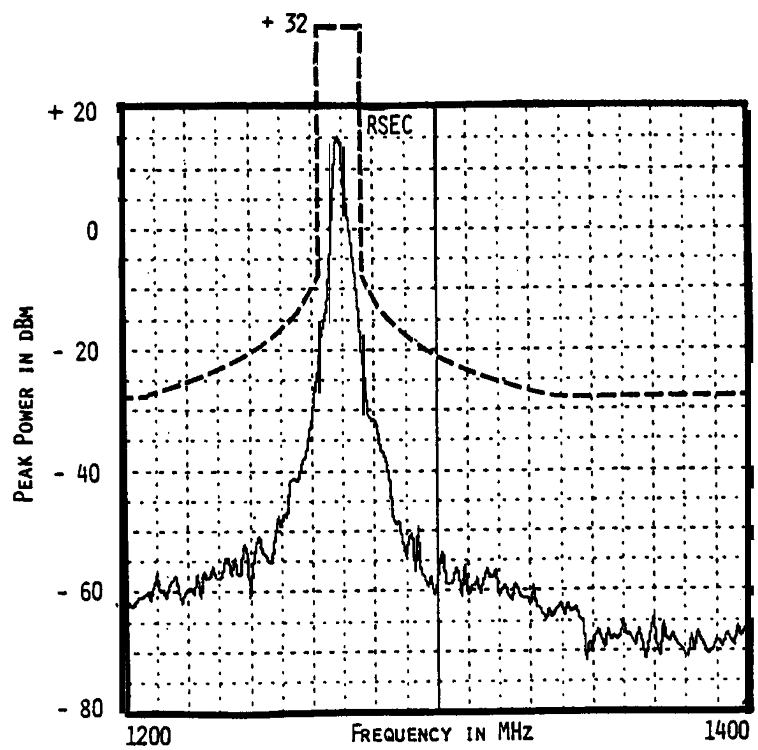


Figure 8. Long-range air route surveillance radar, ARSR-1E.



a. FPS-107, klystron.



b. ARSR-3, klystron.

Figure 9. Long-range search and air route surveillance radars, FPS-107, ARSR-3;

the fundamental frequency. It should be noted that the conventional magnetron was near the end of its recommended operational life when measured, and the coaxial magnetron was measured soon after installation. When comparing the two spectra, some questions are raised. The coaxial magnetron spectrum seems to be an improvement relative to the conventional magnetron. Would a new conventional magnetron have had an equal improvement, except in the “porch area?” Was any other maintenance performed which might have caused a change in output spectra? Above 3380 MHz the coaxial magnetron output is still measurable where the conventional magnetron output has fallen below the measurement system noise level.

A comparison of all of the S-band coaxial magnetron spectra in this section reveals another interesting phenomenon. The coaxial magnetrons also exhibit a characteristic [1, 2, 1] mode “hump” centered approximately 80 MHz above the fundamental. With the exception of the radar in Figure 12a (measured almost immediately after installation), all of the radars fail to meet the RSEC in the “hump” area. This coaxial magnetron characteristic will be discussed further in the next section.

Measurement and analysis parameters, plus additional information about the radar spectra presented in this section, are listed in table 3.

<u>FPS-90 (Fig. 10a). Conventional magnetron</u>. The spectrum of this radar may be compared with the spectrum of figure 12a, which is the same radar after overhaul and installation of a coaxial magnetron.

<u>FPS-90 (Fig. 10b). Conventional magnetron</u>. At the time this spectrum was measured, the radar was nearing its overhaul date and this conventional magnetron was replaced shortly afterwards by a coaxial magnetron.

<u>FPS-90 (Fig. 11a). Conventional magnetron</u>. This spectrum and figure llb represent classic examples of conventional magnetron spectra.

<u>FPS-90 (Fig. 11b). Conventional magnetron</u>. Note that this spectrum was measured in a 300 KHz bandwidth, and there is no correction necessary for the RSEC at the fundamental frequency.

<u>FPS-90 (Fig. 12a). Coaxial magnetron</u>. This spectrum may be compared with figure 10a which is the same radar, prior to modification, when it used a conventional magnetron.

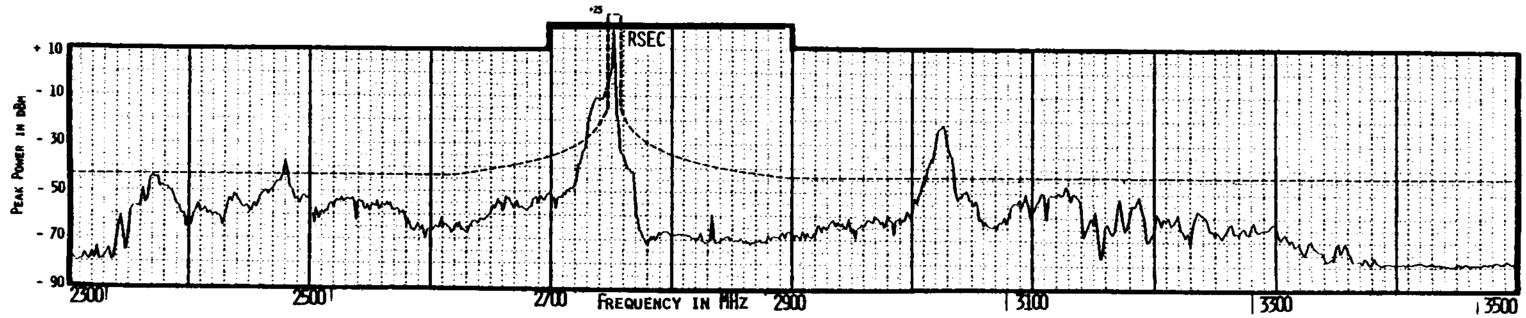
<u>FPS-90 (Fig. 12b). Coaxial magnetron</u>. To save measurement time, fewer data points were used above 3300 MHz hence the less detailed fine structure on the spectrum plot.

<u>FPS-6 (Fig. 13a). Coaxial magnetron</u>. The FPS-6 height-finding radar is essentially the same as the FPS-90 radar except for a mechanical variable-nod

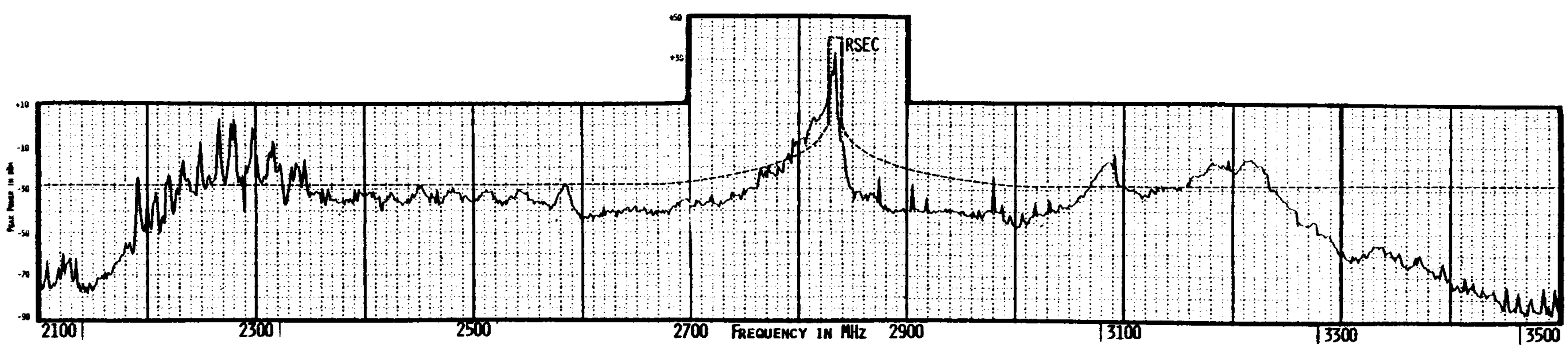
Table 3. **Selected Operational and Measurement Parameters for Height-Finding Radars**

Radar Equipment	Amplifier Type	Operating Frequency (MHz)	Pulse Repetition Rate (pps)	Pulse Duration (μs)	Pulse Rise Time (ns)	Peak Power (dBm)	Measurement Bandwidth(s) (kHz)	Figure Number
FPS-90	Conventional Magnetron	2737 [M]	354 [M]	2 [E]	200 [E]	97 [E]	1000	11a
FPS-90	Conventional Magnetron	2777 [M]	278 [M]	2 [E]	200 [E]	97 [G]	300	11b
FPS-90	Conventional Magnetron	2833 [M]	370 [G]	2 [G]	200 [E]	97 [G]	1000	10b
FPS-90	Conventional Magnetron	2752 [M]	360 [E]	2 [E]	200 [E]	95.5 [E]	1000	10a
FPS-90	Coaxial Magnetron	2752 [M]	363 [M]	2.75 [M]	300 [M]	95.5 [E]	1000	12a
FPS-6	Coaxial Magnetron	2750 [M]	360 [M]	3.6 [M]	275 [M]	95.5 [G]	1000	13a
FPS-90	Coaxial Magnetron	2745 [M]	370 [M]	3 [M]	530 [M]	96 [E]	1000	13b
FPS-90	Coaxial Magnetron	2808 [M]	354 [M]	3.15 [M]	400 [M]	96 [E]	1000	13c
FPS-90	Coaxial Magnetron	2787 [M]	369 [M]	3 [M]	400 [M]	96.5 [G]	3000	12b

[M] – Measured
[E] – Estimated
[G] – From Government Master File

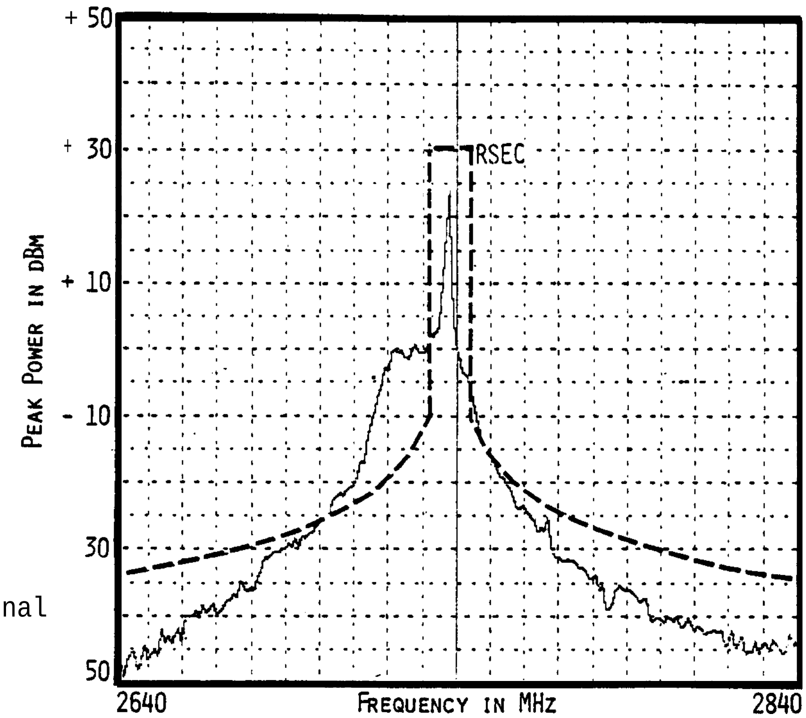


a. FPS-90, conventional magnetron.

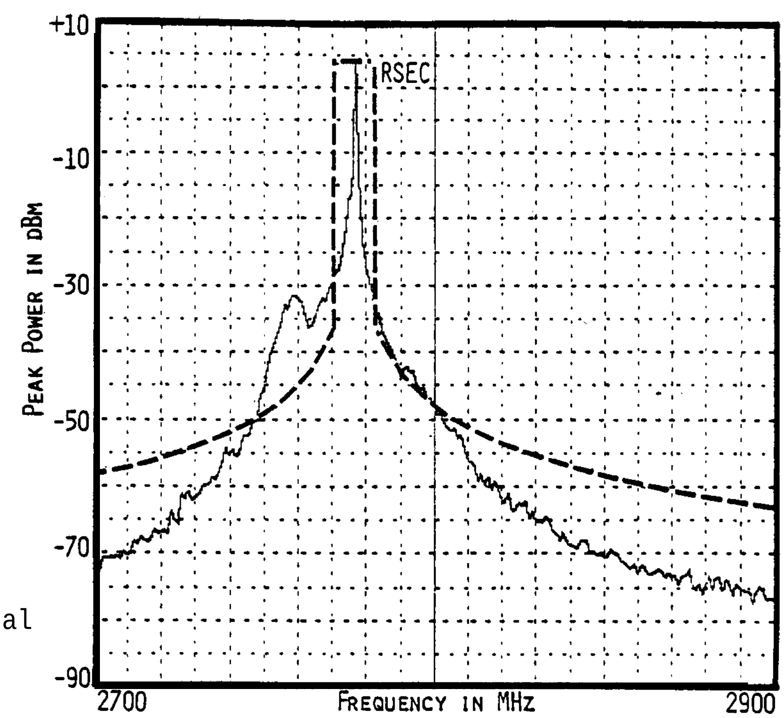


b. FPS-90, conventional magnetron.

Figure 10. Height-finding radars, FPS-90.

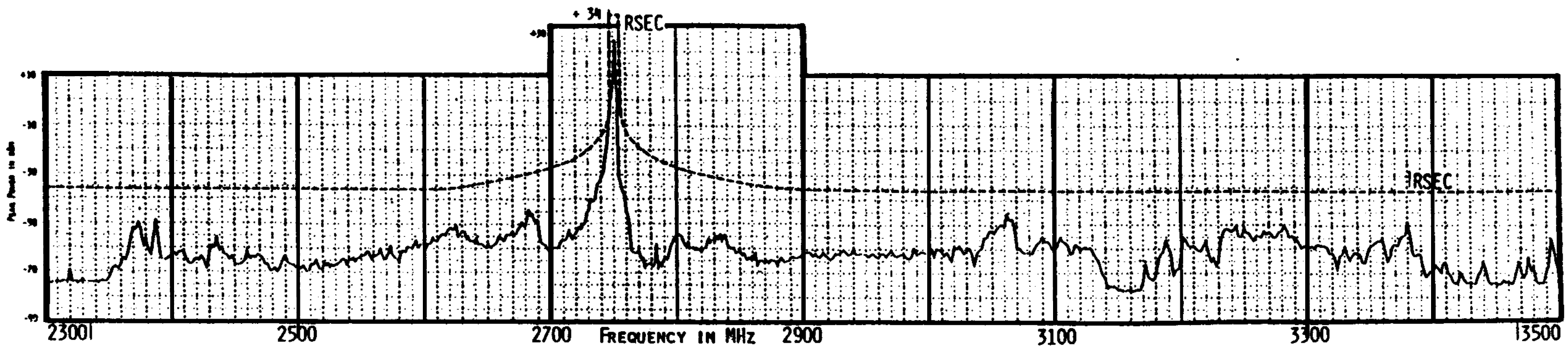


a. FPS-90, conventional magnetron.

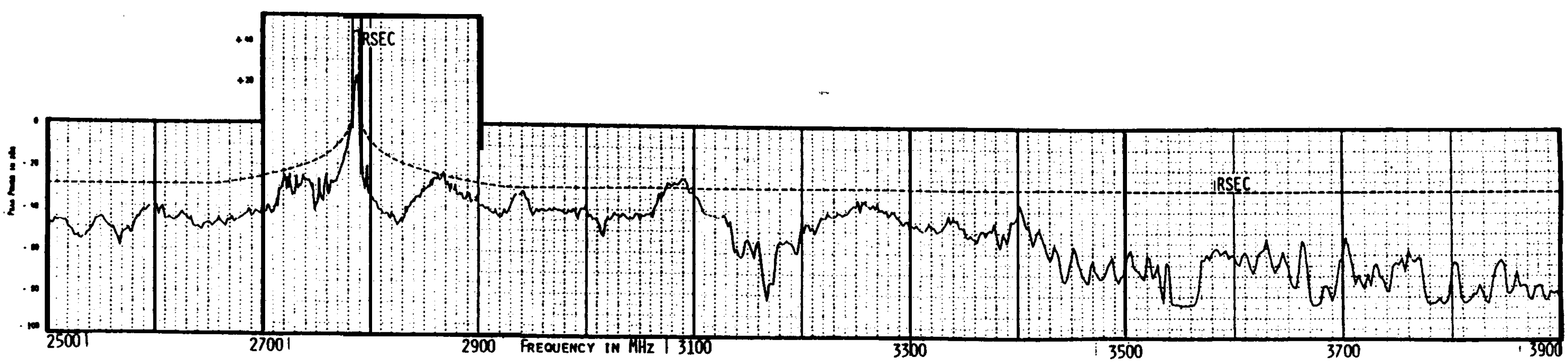


b. FPS-90, conventional magnetron.

Figure 11. Height-finding radars, FPS-90.

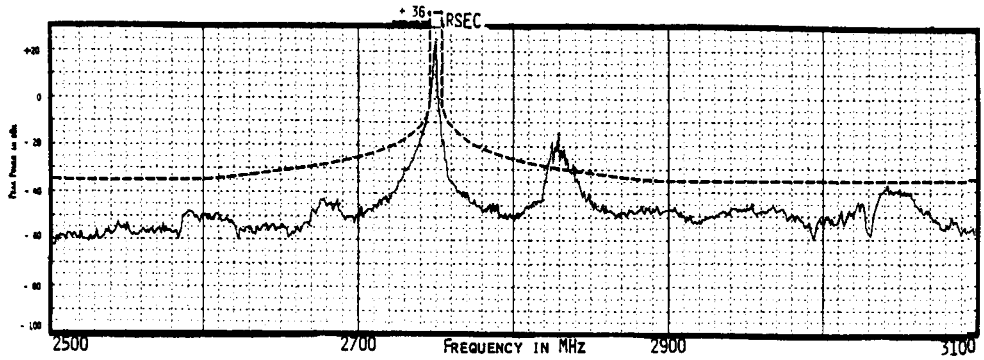


a. FPS-90, coaxial magnetron.

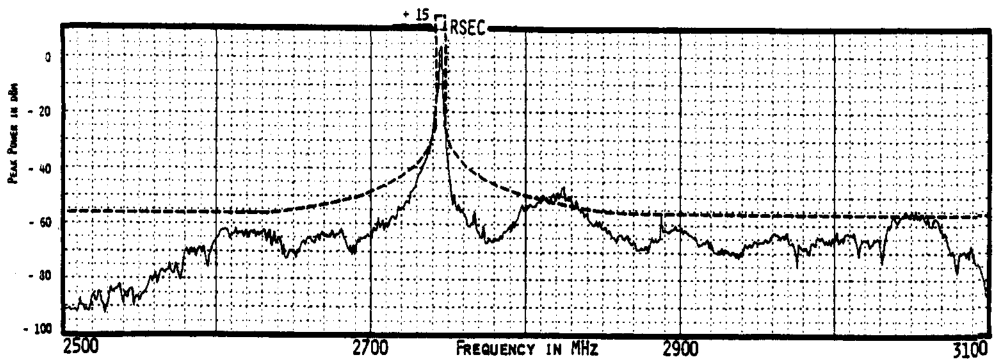


b. FPS-90, coaxial magnetron.

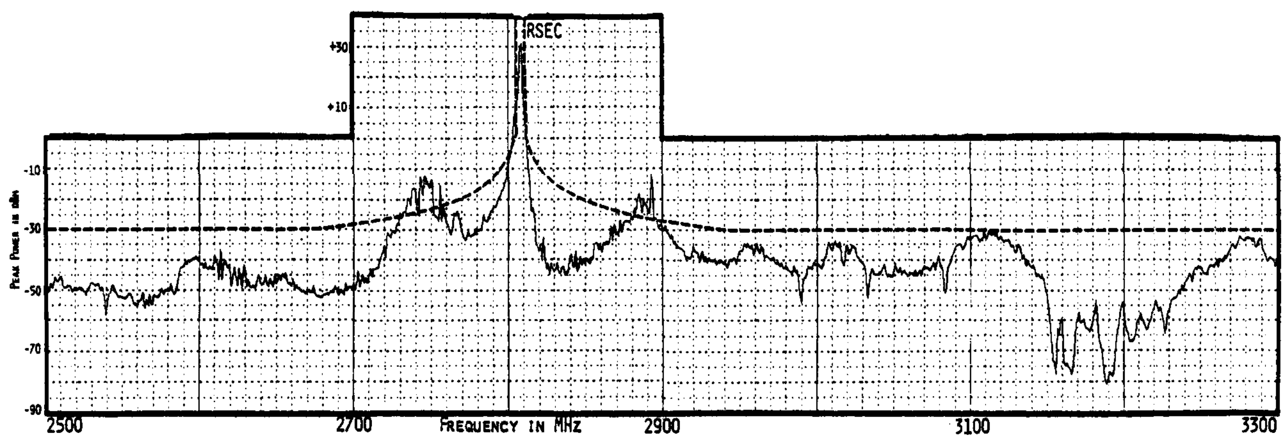
Figure 12. Height-finding radars, FPS-90.



a. FPS-6, coaxial magnetron.



b. FPS-90, coaxial magnetron.



c. FPS-90, coaxial magnetron.

Figure 13. Height-finding radars, FPS-6, FPS-90.

feature in the elevation drive mechanism of the antenna.

FPS-90 (Fig. 13b and c). Coaxial magnetrons. The FPS-90 in figure 13c is distinctive because it exhibits an additional “hump” centered approximately 60 MHz below the fundamental. This characteristic of coaxial magnetrons has been noted, to a lesser extent, on other S-band coaxial magnetrons.

7. SPECTRA OF WEATHER RADARS

This section contains spectra of C-band and S-band weather radars using both conventional and coaxial magnetrons. There are three conventional magnetron spectra, one S-band and two C-band, and ten coaxial magnetron spectra included here. Two of the coaxial spectra (Figs, 15a and b) are measurements of the same radar and were included to show the spectral differences between the long and short transmitted pulse width. Figure 17 contains extended emission spectra of three different radars and illustrates the large amount of spectrum containing potential interference energy. Figures 17a and d are different radars with similar magnetrons and were measured across the frequency spectrum until the received signal level dropped below the measurement system noise level. Figures 17b and 17c are the same radar, measured twice, illustrating the effectiveness of a band reject filter installed to protect a selected portion of the spectrum (5950-6450 MHz).

An area of concern with coaxial magnetrons is the “hump” about 100 MHz (80 MHz, S-band) above the fundamental frequency. This hump is caused by a spurious oscillation mode in the′ coaxial magnetron. It should be noted that the character of the emission changes significantly in this area, and that the particular measurement method which was used here overemphasized the average energy amplitude of the emission spectra for this region. For example, using a minimum measurement period of 0.5 s at each frequency, and a typical PRR of 260 pps, a measurement period at each frequency contained about 130 pulses. Over most of the frequency range each radar pulse produced about the same amount of energy, and it made no difference whether the peak power was measured from one pulse or from 130 pulses. In the “hump” region, however, there was a significant spread in the amount of energy from pulse to pulse, often as much as 20 dB. This spread was easily visible by observing the instantaneous video waveforms before they were processed by the peak detectors. Since the measured spectrum was determined by the peak amplitude of the highest pulse out of the 130 pulses at each frequency in the “hump” region (instead of the peak amplitude of the