The AN/PPS-5 Combat Surveillance Radar

REPRINTED FROM

INTERNATIONAL DEFENSE REVIEW

An INTERAVIA Publication

No. IV/1968

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An operator using an AN/PPS-5 surveillance radar in the field. Here the display is located some 35 feet away from the radar scanner unit.

Introduction of the AN/PPS-5 combat surveillance radar has been largely responsible for a recent upsurge in interest in ground-based radar for battlefield surveillance. Used by the US Army to detect, locate, and identify tactical personnel and vehicle targets, the AN/PPS-5 has recently been made an item of standard issue to the appropriate military units. Over 600 of these radars have been ordered from Cutler-Hammer's Airborne Instruments Laboratory Division as of June 1968.

The AN/PPS-5 incorporates the sophisticated techniques of a fixed radar station, but in a portable version. The AN/PPS-5 provides several operational capabilities:

1. Designed to be separated into three rugged packages, it can be manpacked, dropped by parachute, or transported by a small vehicle.
2. The three packages can be assembled and set up in less than 10 minutes into a radar that requires only 50 watts of power (supplied either by its self-contained rechargeable battery or by an external DC source).
3. It can operate in any combat environment.
4. Its visual displays show targets up to 5,000 metres (for a single individual) and up to 10,000 metres (for a group of men or a small vehicle), and its aural tones classify different types of targets.
5. It offers a choice of automatic operating modes for full area surveillance without the need for manual range or azimuth scanning.
6. It enables the operator to use the radar from a protected location as far as 50 feet from the basic radar unit.

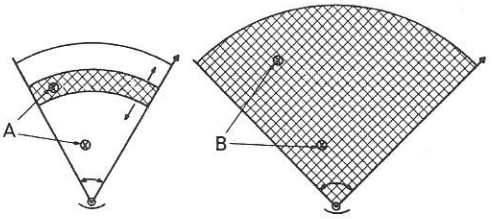
Radars specifically designed to detect personnel targets, first used by the US Army in the late 1950's, detected a doppler beat between a moving personnel target and the fixed surroundings. This beat, in the audio frequency range, was amplified and fed to headphones. An experienced operator, listening to the doppler tones, could classify the general type of target that he had detected-that is, whether it was a man or a group of men, and whether the target was running or crawling. Vehicles also produced characteristic tones; for example, tracked vehicles could be distinguished from wheeled vehicles.

The early radars were operated like a searchlight: a relatively narrow beam (about 6 degrees) was positioned manually in order to illuminate the target with radar pulses. Although targets could be detected at ranges of up to 4 miles, only a narrow segment (about $1/3$ mile wide) could be examined aurally at a time over the limited single-beam position. These factors, combined with the relatively heavy and bulky design of the vacuum-tube era, limited the effectiveness of the personnel detection radar. Although a later transistorised version of one of these radars was built, it did not solve the basic problems of limited area coverage and detection solely by aural tones.

In the early 1960's, the US Army embarked on a programme implemented by Cutler-Hammer's Airborne Instruments Laboratory (AIL) Division to develop a modern, portable, rugged, and effective personnel and vehicle detection radar that would fully exploit the capabilities of this type of radar. That this goal has been successfully achieved is borne out by the results obtained with the AN/PPS-5 in Vietnam operations. The radar has been highly successful in ferreting out enemy movements, particularly at night and under conditions of poor visibility.

The AN/PPS-5 solves the major problems of personnel detection radars by providing

This diagram illustrates the improvement in surveillance capability obtained with the AN/PPS-5. The sketch on the left shows the coverage of earlier types of radar using a manually movable range band that scanned a narrow radial segment. This type of coverage is limited by the requirement to dwell on a target for an appreciable fraction of a second to ensure detection. In contrast, the visual displays and the MTI system in the AN/PPS-5 provide continuous coverage at all ranges, essentially simultaneously. A - earlier system showing only one target detected. B - the complete sector area coverage of the AN/PPS-5 with both targets detected. The operator can then set the range gate on each target in turn and aurally identify the type of target.



The basic radar unit weighs 56 lb and requires only 42 watts of power. Used alone the basic radar provides aural surveillance. The scanning head of the AN/PPS-5 is engineered to be inaudible at a distance of 15 metres when in operation.

automatic sector azimuth scanning and range coverage with visual display of moving targets over the entire sector under line-of-sight surveillance. This comprehensive range coverage was made possible by the development of a compact, highly efficient MTI (moving target indicator) system that effectively removes fixed targets, displaying only those targets that are moving. These features enable the AN/PPS-5 to cover an area ten times as large as that covered by earlier personnel detection radars.

During the period of field testing, the AN/PPS-5 detected small boats, swimmers, and even the motions of a man washing his car (fascinating doppler tones). It can also distinguish between objects of about the same size on the basis of their characteristic movements; for example, the AN/PPS-5 can distinguish between a water buffalo and an infantryman.

Operators who are required to concentrate on listening for doppler tones that would indicate the detection of targets tire after about twenty minutes. The addition of a visual display reduces this fatigue factor: the operator can observe the screen for several hours without tiring, and alertly use the doppler tones to classify the targets detected on the visual display.

The AN/PPS-5 incorporates several techniques in an unique design. For example, fully synchronized operation eliminates electrical disturbances that cause performance to deteriorate. A range-gated filter MTI processor is especially suitable for detecting targets moving as slowly as 1 mile per hour. Solid-state circuits (except in the transmitter and the displays) result in low power requirements (50 watts). Operation while scanning is silent.

The antenna reflector is of a fibreglass

The remote unit of the radar in operation in the field. With the two visual displays the operator can maintain surveillance on multiple targets within the scanned sector up to a range of 10,000 metres.

honeycomb design. Signals are duplexed by means of a ferrite circulator and solid-state crystal protector coupled into a balanced mixer. The local oscillator is unique. A tunable 2 Gc oscillator was developed that has a very low input power requirement (2.5 watts total) and provides an output greater than 100 mw; this output is multiplied by eight in a single-stage broadband varactor multiplier to provide a local-oscillator signal at the radar operating frequency.

Automatic Frequency Control (AFC) is obtained from a second mixer operating from a coupler in the side wall of the circulator. The AFC mixer is operated unconventionally to conserve local-oscillator power. The high-level signal is the pulse from the magnetron, and the low-level signal is the local-oscillator signal. The local oscillator is tuned by the output of the AFC, using a second varactor as a variable capacitor loosely coupled to the oscillator. The basic receiver uses a lin-log IF amplifier, whose output is used to drive both the aural and the visual doppler processors.

The Control/Indicator unit provides remote control of the radar set with the appropriate read-out and control devices as well as visual displays of the full 10,000-metre range on both MTI and normal displays (A-scope and B-scope).

Target range is measured by a manually-controlled magneto-strictive delay line coupled to a counter; this system was selected instead of the more conventional pulse-delay system because it permits stable calibration without having to add calibrators and to make slope, zero and other adjustments. Target range is measured by a manual range control knob coupled to a direct-reading range counter. A range mark on the display scope shows the position of the range gate. Thus, the range gate for the aural doppler processor can be moved by the range crank to a position over the target located on the display scope. When the desired target is located in azimuth, the antenna is stopped at the target azimuth and the signal is peaked in the headphones. Target coordinates are then read out on the range and angle counters.

An aural doppler processor consisting of

a clutter filter and audio amplifier drives the headphones. The audio amplifier, which uses selective limiting to hold down strong signals and transients, has a frequency response that compensates for the combined frequency response of the headphone and ear to obtain equal signal intensity at all frequencies in the doppler range of interest (50 to 1,700 Hz). The limiting action occurs mainly on low-frequency signals and accentuates higher-order harmonics, thereby enhancing recognition of low-speed targets.

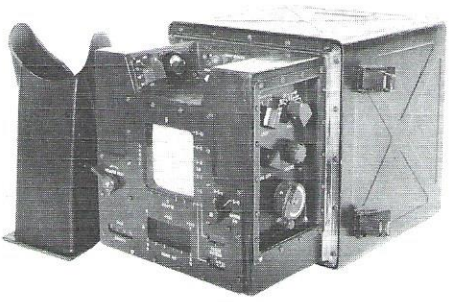
A 50-channel range-gated-filter system is used to provide MTI over a 5,000 metre range. Each range-gated filter channel in the system sequentially covers a 100-metre range increment. Each channel is identical in design. The outputs from the fifty filters are added to provide MTI video for the displays.

Internal protection is provided in the power supply so that, regardless of the method of connection (using the same set of leads), the radar cannot be turned on until the battery connections have been made properly and the voltage input is within the proper range.

The selectable scan speeds are held relatively constant by a feedback motor-speed control circuit that supplies only enough power to meet the demand in the presence of varying wind loads; this conserves power.

Azimuth coordinate readout is obtained remotely from a follow-up servo that repeats the antenna position data. To minimise power consumption, this control is used on demand by the operator only when fine azimuth data is desired.

Extensive testing has proved that the AN/PPS-5 is rugged enough to withstand rough field handling and repeated submersion, though its lightweight design does not use a massive structure for support. To achieve this light weight, magnesium (with appropriate protection to comply with salt-fog specifications) is used extensively throughout for cases, castings, etc. In spite of its relatively small size, the AN/PPS-5 uses over 500 transistor circuits.



Addition of the remote unit shown here to the basic radar provides both aural and visual surveillance. The remote unit weighs 35 lb and requires only 15 watts of power. On the front of the unit can be seen the A and the B scopes, together with the digital range and azimuth readouts.

The AN/PPS-5 is designed on a modular basis and includes integral test facilities so that faults can be readily located to the module level without extensive test equipment. The modules can be replaced using small hand tools.

The AN/PPS-5 has shown much versatility in its use as a manpacked radar, on towers, and even in trees. One version of the radar set has been equipped with a 360-degree scan and a PPI display kit for the US Army Special Forces. Another version of the radar set has been installed in a vehicle and used for perimeter protection of air-bases. The AN/PPS-5 is being evaluated for airborne applications where flexible vantage points will further enhance its effectiveness.

Airborne Instruments Laboratory is working on a programme to take advantage of some recent technical advances to provide equal or better surveillance in a radar less than one-third the size and weight of the AN/PPS-5. ✦✦

Technical Characteristics of the AN/PPS-5

Power input, receiver/transmitter only	42 watts Internal 6-volt battery or external
Power input, receiver/transmitter with remote unit	57 watts 6- or 24-volt DC source
Range	
Maximum	Individual personnel—5,000 metres; vehicles—10,000 metres
Minimum	50 metres
Resolution	40 metres
Accuracy	±20 metres
Azimuth accuracy	±10 mils
Elevation coverage	—600 to +400 mils
Elevation accuracy	±30 mils
Transmitting System	
Frequency	16.0—16.5 GHz (tunable)
Peak power	1 kw
Pulse repetition rate	4,000 pps ±5 per cent
Pulse width	0.25 μsec
RF System	
Reflector	Parabolic contour (13.4×42 inches)
Horizontal beamwidth	1.15° (nominal)
Vertical beamwidth	3.5° (nominal)
Polarization	Horizontal
Receiving System	
Overall noise figure	14 db
IF amplifier	Linear-logarithmic
Intermediate frequency	60 MHz
Bandwidth	5 MHz
Audio bandwidth	50 to 1,700 Hz
Indicating System	
B-scope	
Presentation	Intensity-modulated display, 3×3 inches
Sweep length	5,000 metres
Range marker (movable)	Intensified range gate
Azimuth scale	Width of display corresponds to sector width used
A-scope	
Presentation	Deflection-modulated display, 1×3 inches
Sweep length (manually selectable)	Long—5,000 metres; short—600 metres
Range marker (movable)	Intensified range gate
Display video	MTI or normal (manually selectable)
MTI system	Range gated filter bank (50 filters, 100-metre resolution)
Equipment Size	
Basic radar	
Radar compartment	5-1/2×10×21 inches (includes bottom cover and storage facilities for headphones, telescope)
Antenna (in two sections)	13-1/2×21 inches each
Battery box	7×4-1/2×9 inches
Remote unit	16×10×10 inches
Environmental Tests	
Temperature	—25 to +125° F with solar radiation
Shock (with transport case)	4-foot drop on concrete covered with planking (repeated drops)
Vibration	55 cps (2 g)
Submersion-proofing (without transport case)	2 hours, 3 feet of water
Wind loading	Full operation at 35 mph wind velocity with 50 mph gust loading