Westinghouse

DAR

Defense Acquisition Radar

Thomas I. Powell Marketing Manager
Tactical Radar Systems
Command & Control Division

Westinghouse Defense and Electronic Systems Center Post Office Box 1897 Baltimore, Maryland 21203 (301)765-6864

Defense Acquisition Radar (DAR)

Designed, Manufactured, and Supported

By

WESTINGHOUSE DEFENSE AND ELECTRONIC SYSTEMS CENTER
Command and Control Division
Baltimore, Maryland 21203

The Westinghouse DAR

Proven Capability

3-D Detection

High Performance

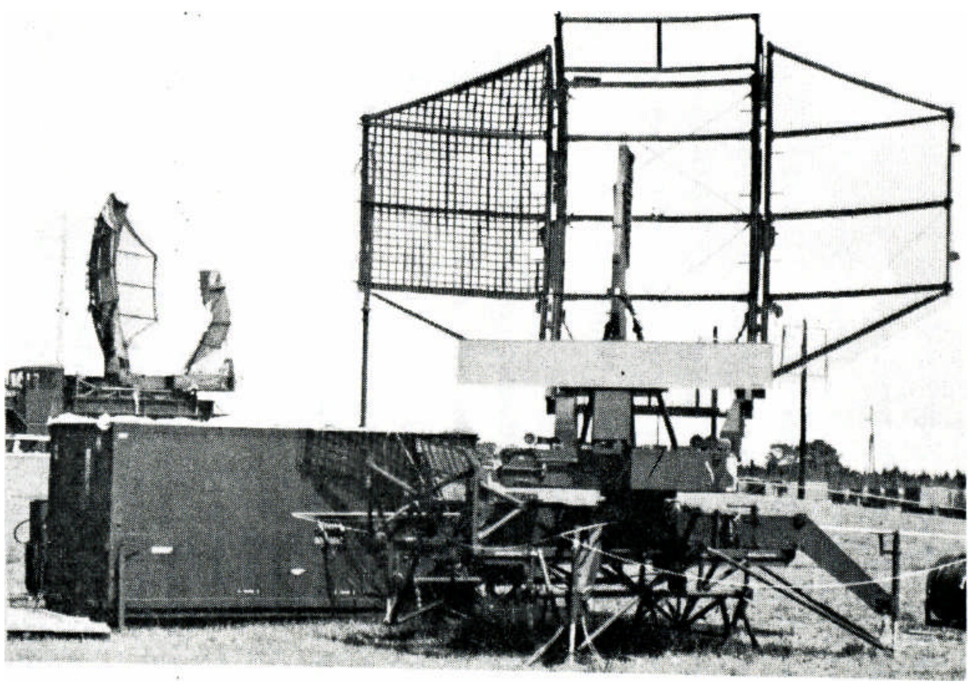
Mobility

Remoting

Digital Electronics

Minimum Personnel

Full Logistics Support



INTRODUCTION

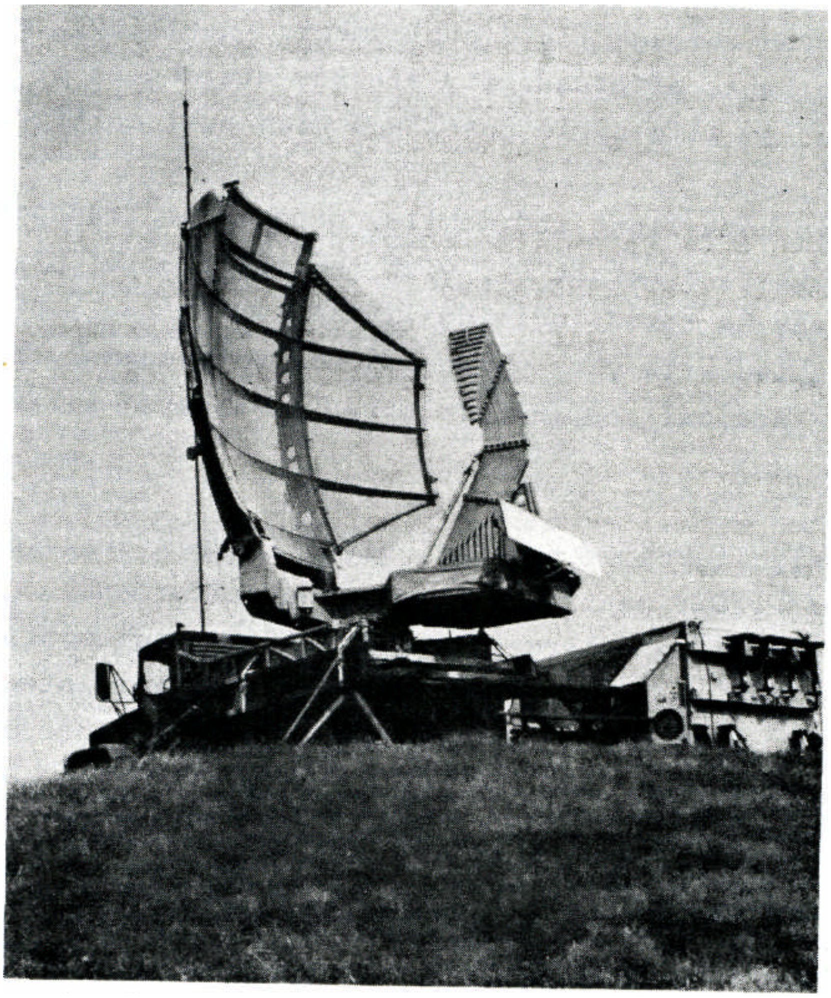
The Westinghouse Defense Acquisition Radar (DAR) is the latest of a series of high performance, long-range, three-dimensional, tactical air surveillance radars. Evolved from the highly successful TPS-43E radar, the DAR incorporates state-of-the-art techniques in transmitters, receiver-processors, IFF/SIF equipment, displays, and digital target extractors -- all of which are proven through field deployment. Mobility, reliability, and very important, affordability are key attributes of the DAR which lead to low life-cycle costs and high availability.

The DAR is both light and mobile, capable of transport by truck, helicopter, aircraft or, with the addition of M720 mobilizers, may be towed individually as two units. This mobility, coupled with very short assembly/disassembly times provides the tactical response required in todays' air defense environment.

Further highlights of the DAR, given in this overview, will show that this radar meets or exceeds the performance characteristics of much larger, heavier, fixed and mobile radars, and may be configured for autonomous operation, or integrated with semi-automatic or fully automatic Tactical Air Defense System Operation Centers.

THE AN/TPS-43 SERIES OF RADARS

THE MOST SUCCESSFUL 3D RADAR IN THE WORLD
USED BY 17 COUNTRIES



WORLD WIDE DEPLOYMENT

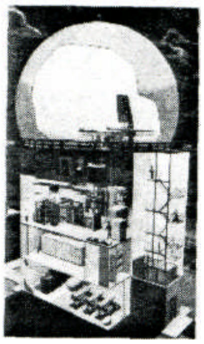
To date, seventeen nations have looked to Westinghouse as a principal supplier of tactical 3-D radars, and the number of units delivered under the heading of "TPS-43" has grown to more than 145 systems.

The term "AN/TPS-43" has come into use to describe what are now nine generations of these tactical 3-D radars. Continuous product improvements and the infusion of new technology have resulted in pacing state-of-the-art performance capabilities. The DAR is the derivative of these improvements which have been gained from extensive field use and from state-of-the-art technology developed on other sophisticated Westinghouse radar systems.

The high performance and modern technology of DAR is achieved without risk on the part of the purchaser. The equipment and circuitry is fully developed and proven. Complete manufacturing drawings, processes, and specifications are available.

Moreover, total logistics support is available for these products covering training, spares, repair, overhaul, and field engineering services. Each area of support is tailored to the individual needs of the purchaser.

Westinghouse Experience



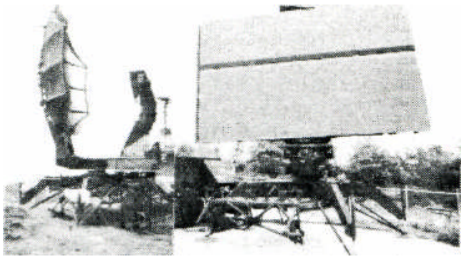
AN/FPS-27

F~4

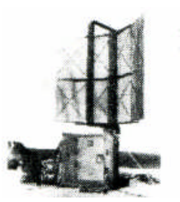
F-16

ARSK-3 ASR-3Q
ADS-4

E-3A



AN/TPS-43 Family



AN/IPS-63/65

BACKGROUND

Westinghouse has 40 years of leadership experience in the manufacture of radar systems. From the first simple radars manufactured in the early 1940's Westinghouse has produced over 35,000 radar sets.

Westinghouse receiver/processor and MTI systems have evolved from air, ground, and shipboard radar applications which have paced the state-of-the-art in detection, clutter rejection, ECCM/WX treatment, and post-processing capability.

High power radar transmitter technology at Westinghouse has grown from experience with several long range high performance radars including the AN/FPS-77, ARSR-3, ASR-30, ADS-4, TPS-43, TRACS, and the E-3A AWACS radar.

The E-3A AWACS radar is but one example of the Westinghouse ability to manufacture sophisticated radar antenna systems.

Westinghouse has developed and manufactured many shipboard radars as well as range instrumentation and tracking radars. We have built radars used in the space program to permit orbiting spacecraft to locate each other and to provide guidance for docking one to the other.

The techniques employed to guarantee the reliability of radar systems used in space satellites and in airborne radars is applied to Westinghouse Ground Radar Systems.

All of these skills and developments of Westinghouse have gone into DAR to make it a high performance, rugged, reliable, and cost effective radar system.

SALES HISTORY OF AN/TPS-43 RADARS

MODEL	CUSTOMER	QUANTITY
Basic Radar	USAF	19
A Model	International (FMS)	4
	International (FMS)	3
B Model	International (FMS)	5
C Model	International (FMS)	5
	International Direct	3
CX Model	International Direct	2
D Model	USAF (FMS)	1
	International	2
DX Model	International Direct	1
E Model	USAF	57
F(VI) Model	International (FMS)	3
F(V2) Model	International (FMS)	3
	International Direct	2
F(V3) Model	International (FMS)	5
F(V4) Model	International (FMS)	2
F(V5) Model	International (FMS)	4
F(V6) Model G	International (FMS)	2
Model	International (FMS)	8
M Model 430	International Direct	4
Model DAR	International Direct	13
Model	International Direct	154

SALES HISTORY

The sales history of the AN/TPS-43 series of radars is shown on the chart on the opposite page and includes USAF and foreign military sales (FMS).

As each new model was developed improvements were made in accordance with new technology available. The application of new technology was applied to the areas where the greatest improvements could be achieved based on the operation of the earlier models in actual field use. There is no other tactical 3D radar which has had the opportunity for such improvement based on operating experience.

The modifications and improvements put into the AN/TPS-43 radar series also considered the changing mission requirements introduced by developments in equipment associated with the radar.

The original AN/TPS-43 radar developed for the US Air Force placed most emphasis on high mobility and light weight with performance adequate for manual air defense operations. Since the original design, performance requirements have increased to meet the demands of supplying information for Automated Air Defense Operations. Improved lift capabilities and larger transport vehicles enabled the radar weight to be increased, allowing better performance and more operating capability to be included in the radar while maintaining the same mobility.

The improvements to the new models developed were incorporated in an orderly manner to achieve the present DAR - The Best of The AN/TPS-^3 Series of Radars.

PROGRESSIVE IMPROVEMENTS TO THE AN/TPS-43 SERIES
OF TACTICAL 3D RADAR

PROGRESSIVE IMPROVEMENTS TO THE AN/TPS-43 SERIES OF TACTICAL 3D RADARS

AN/TPS-43A (Foreign Govt's)

New Multi-channel Digital MTI

Added antenna tilt

New heat exchanger remotely located

Environment improvements

Replaced IFF interrogator with latest AIMS approved model (UPX-23)

AN/TPS-43B (Foreign Govt's)

Equipment shelter enlarged to Std.S-280 size

Added workbench in shelter

Redesigned TWT hoist

Air Conditioner relocated outside shelter

Variable amplitude test targets added

Redesigned transmitter mechanical layout

New transmitter heat exchanger for improved R/M

AN/TPS-43C (Foreign Govt's)

Relocated IFF equipment within shelter

Improved focus coil power supply

Improved Dual thyratron trigger amplifier

Waveguide pressurization improvement

Replaced small monitor PPI with 16-inch AN/UPA-62 Operational PPI

Replaced KY-364 Passive IFF Decoder with AN/UPA-59A Active Decoder including Mode C IFF height

Improved Transmitter heat exchanger for increased reliability/maintainability

AN/TPS-43D (USAF and Foreign Govt's)

Added ISLS antenna system (IFF)

R/M Improvements to DMTI

Solid-state (improved N.F.) RF Amplifiers in receivers, improved R/M

Maximum detection range extended to 240 naut. miles (445 Km)

Improved search detection from multiple-channel digital integrators

AN/TPS-43E (USAF) AN/TPS-43F (VI-V6) (Foreign Govt's)

Fourteen foot shelter includes two operational air controller positions each with AN/UPA-62 PPI, Height Readout, active/passive IFF, communications controls, telephones

Includes built-in HF and UHF communications equipment, providing total FACP capabilities in single package

Redesign includes improved and simplified Unit Receiver/Digital Processor with 6:1 reduction in circuit cards and 2:1 reduction in types of circuits. Includes improved BITE

Remote control of transmitter radiation

Improved search detection from multiple-channel detection and multiple-channel digital integrators; improved interference rejection, improved receiver noise figure. Includes Weather/ECM video

Increased reliability and improved maintainability through new circuits, simplification, and increased BITE

Provisions for addition of Digital Target Extractor (DTE) giving narrow band digital target reports

AN/TPS-43(M) (Foreign Govt's)

Improved digital MTI with 10-bit, 4-pulse cancellers for increased dynamic range and increased cancellation

High resolution automatic clutter map selects MTI processing in regions of clutter

MTI enabled height computation in clutter regions under control of clutter mapper

Fully solid-state modulator used for radar transmitter. Transmitter enclosure has revised layout for improved accessibility

Digital Target Extractor (DTE) installed to provide 3D radar and IFF digital plots to remote automatic tracker

Solid-state digital PPI's, UPA-( ), installed for radar/IFF analog display and DTE and digital track display. Includes keyboard for input to display and tracking computers

Increased BITE in digital processing and DTE

Auxiliary readout at each PPI for display of alpha/numeric data from tracker

Fully solid-state IFF incorporates interrogator, defruiter, ISLS switching and control and BITE in a single unit in place of separate units. Increased IFF reliablity and reduced size and weight

AN/TPS-43 DAR (Foreign Govt's)

Improved Digital MTI includes I&Q processing for improved MTI detectability and higher radar PRF to improve clutter rejection

Transmitter and frequency generator stability improved to complement better MTI capability

Array Signal Processor Digital Target Extractor (ASP DTE) added for greater flexibility in output data formatting and increased automation capability

New high reliability components installed in receiver processor to improve MTBF

Modems added in radar shelter to facilitate data transfer

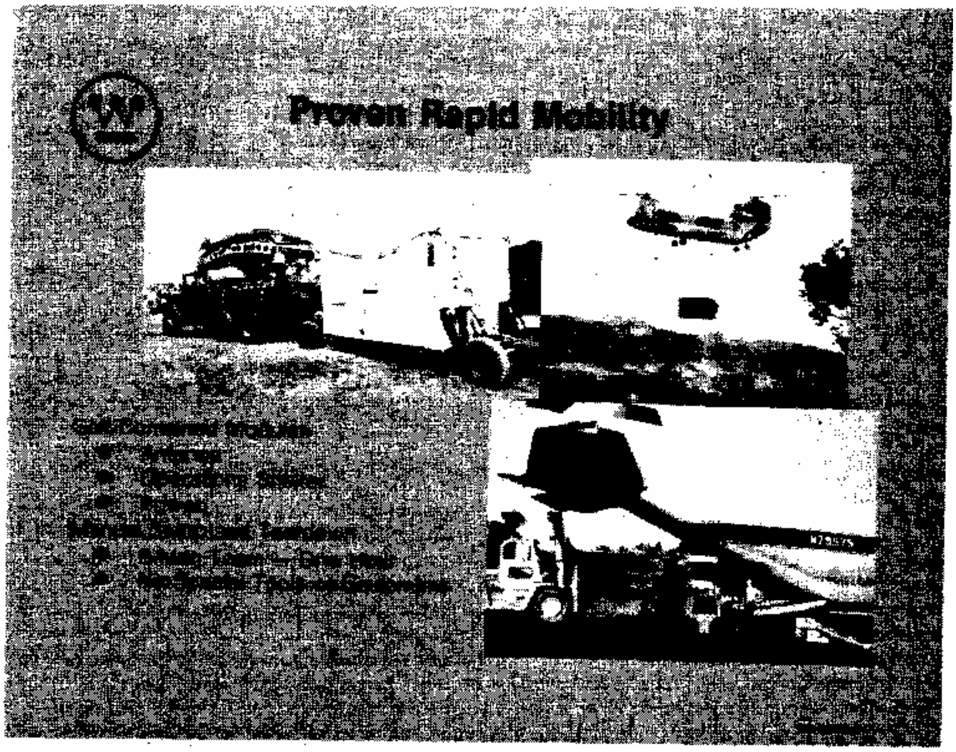
PROGRESSIVE IMPROVEMENTS

The table on the opposite page lists the major changes incorporated into the new models as they were developed and built. Improvements in performance and reliability included in one model are retained in the later models. The most significant improvements relate to reliability and maintainability and to MTI performance.

Additional built-in test equipment (BITE) enables lower skill level maintenance personnel to perform maintenance by replacing failed assemblies as indicated by the BITE. Modifications to increase reliability, introduced into the AN/TPS-43M and the AN/TPS-43 DAR, including the solid state transmitter modulator, the solid state IFF subsystem, and the use of new high reliability components have increased the radar MTBF to 400 hours.

The in-phase and quadrature (I&Q) processing used in the DAR MTI coupled with the higher pulse repetition frequency (PRF) increase MTI improvement factor to more than 40 db and increase MTI detectability by 5 db.

Post-processing and display improvements, such as the microprocessor-based array signal processing DTE and the AN/UYQ-27(V) series random access PPI displays, have substantially augmented the output performance of the radar. In addition, a new solid-state IFF (SSIFF) unit is now offered as standard equipment. This latter unit is 1/3 the size and weight of previous IFF equipment and has all test equipment built-in.



Shelter

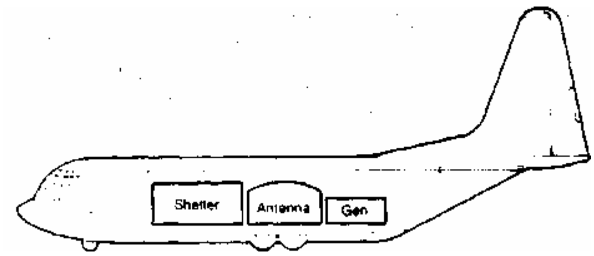
4.5 x 2.3 x 2.3 meters
3200 KG

Antenna Module

3.8 x 2.3 x 2.3 meters
1800 KG

C-130

80-0530-B-9



MOBILITY

DAR has the highest tactical mobility of any high performance air surveillance radar. It can be deployed by sea transportation or a single C-130 aircraft, and can be transported to sites by helicopter or by combinations of trucks and wheeled dollies.

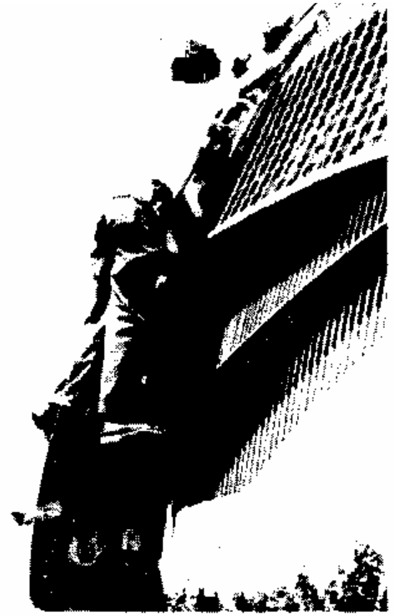
Mobility is achieved by minimum size, weight and simplicity. In the transport configuration the DAR consists of two standard sized units: the antenna and microwave system which fold into an integral transit pallet, and the radar shelter in which the air conditioners and heat exchanger are stowed. The primary power generators are carried separately. Lifting eyes and slings are provided with each unit.

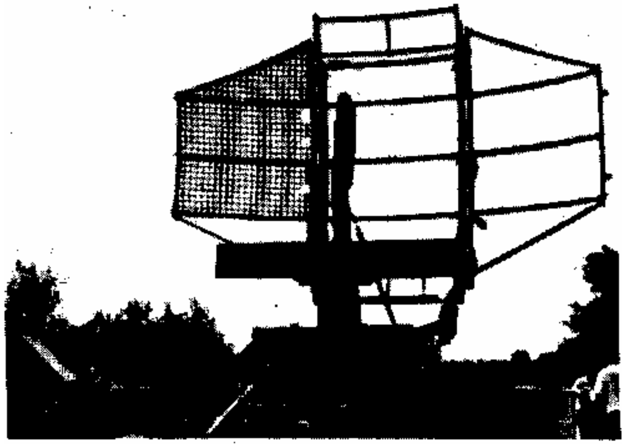
Tactical mobility has been fully demonstrated during qualification testing of the AN/TPS-43 radar set followed by many C-130 airlifts and extensive field deployment.

Designed from inception as a lightweight system, the DAR can serve several operational requirements ranging from point surveillance sensor for air defense groups to fully autonomous operations for GCI/survei1lance purposes with remoting capability to Sector Operations Centers. DAR mobility means rapid response to either a changing role or to a changing threat (to negate pre-targeting).

FOLDABLE COMPONENTS

IFF ANTENNA INSTALLATION





RAPID INTERCONNECTION

Rapid Antenna

Erection

EMPLACEMENT

The photographs on the opposite page show the erection of the antenna in various stages of the sequence. From the time the radar is delivered to a site a six man crew can place the radar in full operation in less than one hour. No special tools or handling equipment is required.

The time required to prepare a radar for moving from a fully operational state is only 30 minutes for a six man crew. Again no special tools or handling equipment is required.

The radar may be set up to operate on unprepared ground with slopes of less than 10 degrees or it can be operated from the bed of a truck or on standard wheeled transporters (mobilizers).

The mechanical design of the antenna has been improved in several ways since the earlier AN/TPS-43 radar sets were built; however, the basic mechanical design and procedures for set up and folding down remain unchanged and have been proven through years of successful service. Leveling jacks on the antenna pallet provide the means to set the antenna level within 0.5 degree. The height computer then automatically compensates for platform tilt within 0.5 degree. It is also possible to adjust the antenna for fixed tilts from + 3° to -1.5° in 0.5° steps (for special terrain purposes); the height computer is directed to compensate accordingly for the set-in tilt.

3D Detection/Small Targets *ff* = 2m2to439km

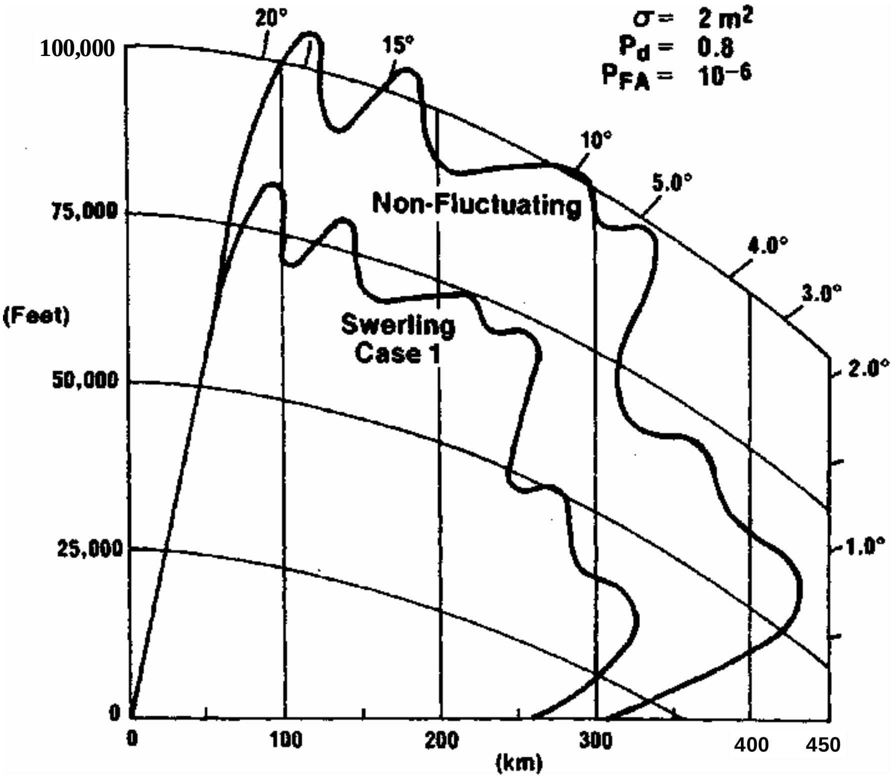
Monopulse Height Finding

Full Coverage MTI Improvement = 40 dB

Effective ECCM CPACS/CFAR Full Freq Agility Growth Capability

Data Rate = 10 seconds

High Resolution Target Extraction DTE and Remoting



RANGE ELEVATION COVERAGE

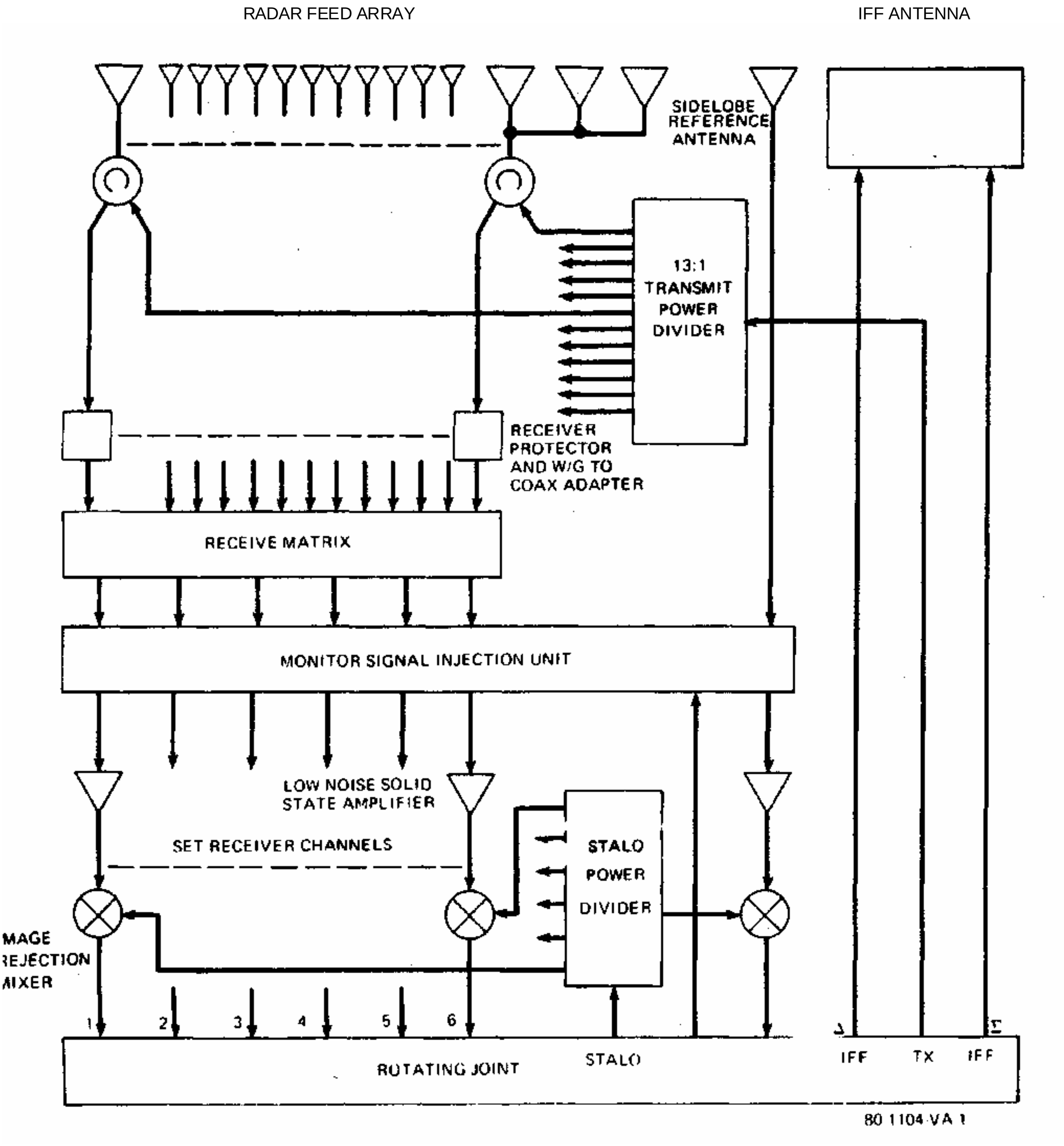
The radar coverage diagram for DAR is shown on the opposite page. The radar has an instrumented range of 240 nautical miles (nm) corresponding to approximately 450 KM.

The outer contour shown on the diagram represents the detection range for a medium sized bomber type aircraft for an 80% probability of detection (PD) and a false alarm rate of 10" for a Swerling Case 1 Target. A Swerling Case 1 Target is representative of a jet aircraft and takes into account the adverse affects of target scintillation. The inner contour on the diagram shows the coverage for 80% PD on a small fighter aircraft with a false alarm rate of 10 and again for Swerling Case 1.

Height accuracy is +460 meters at a range of 185 Km.

One of the very significant advantages of DAR over competing radars is that DAR provides full-time, full-range MTI and ECCM performance and does not require special modes of operation with reduced coverage to counter jamming or clutter.

DAR ANTENNA SYSTEM



ANTENNA SYSTEM

The block diagram for the DAR antenna system is shown to the left. The transmitted S-band radar pulse passes through the high-power section of the rotary joint. This joint also contains two low-power S-band sections for the stable local oscillator (STAL01 power to the receiver mixers and the test and calibration signal for injection into each received path. Synchro generators and the azimuth change pulse (ACPV generator are mounted on the rotary joint gear box.

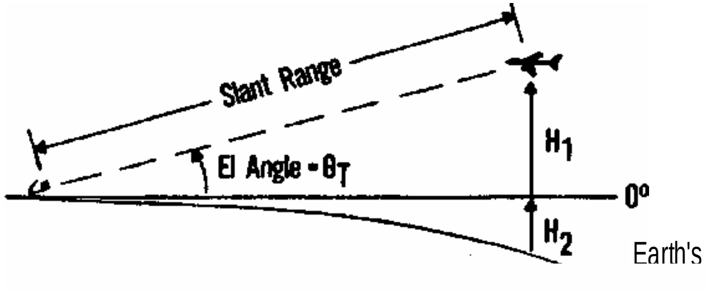
The transmitted pulse enters a waveguide coupler and two waveguide power dividers after passing through the rotary joint. These divide the power into thirteen separate outputs to feed the thirteen waveguides going to the feed array. These dividers place the highest power at low elevation angles for best long range detection. The transmitter energy in each channel then passes through waveguide circulators before entering the individual feedhorns. The in-phase addition of the output from each feedhorn produces the composite transmitted pattern. This energy is then focused by the parabolic reflector.

Received signals are focused on the feed array and enter several of the fifteen horns of the array. Horns 13, 14 and 15 are connected together and perform as one. The resulting thirteen waveguides feed signals to the receiver microwave matrix which combines the received energy from one or more horns into six separate outputs. Each of the six receiving channels includes a low noise receiving solid-state amplifier and image rejection mixer. The IF outputs from the mixers are fed to separate IF slip rings in the rotary joint and are connected by coaxial cable to the radar shelter.

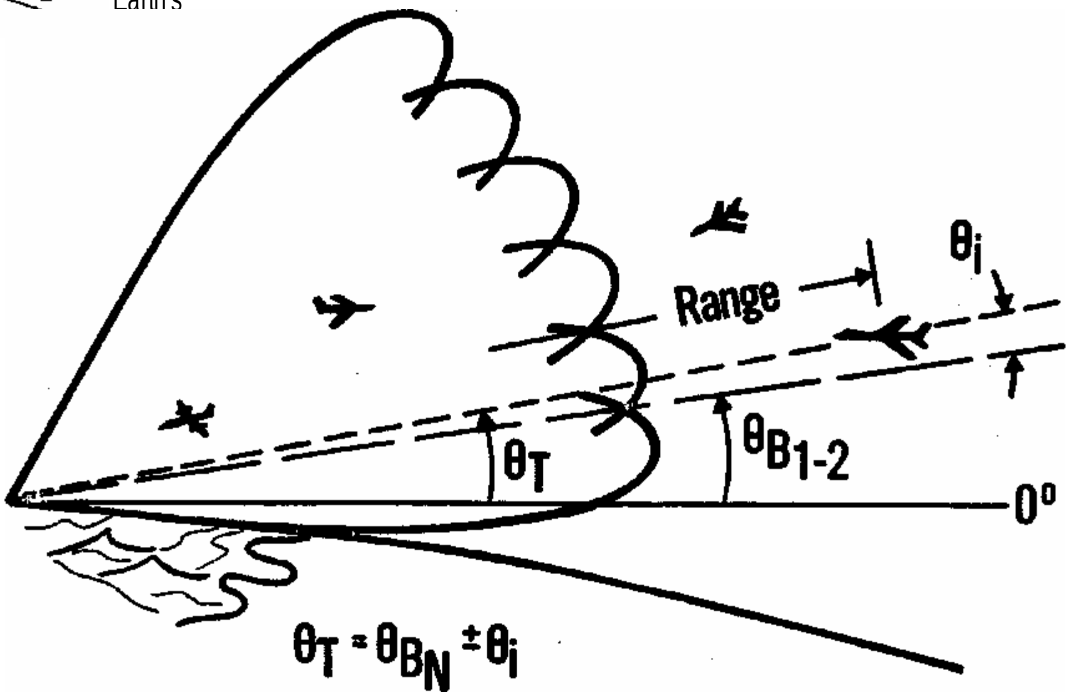
A microwave coupler is included to allow an RF monitor pulse to be injected into the RF receiver circuits. The monitor pulse allows monitoring of the performance of each receiving path.

A sidelobe reference antenna is mounted on the antenna assembly. The pattern coverage of this antnena approximately encompasses the sidelobe structure of the radar antenna and is used to minimize the detection of targets in the radar antenna sidelobes.

Basic Height Rnding



DAR   Monopulse Height



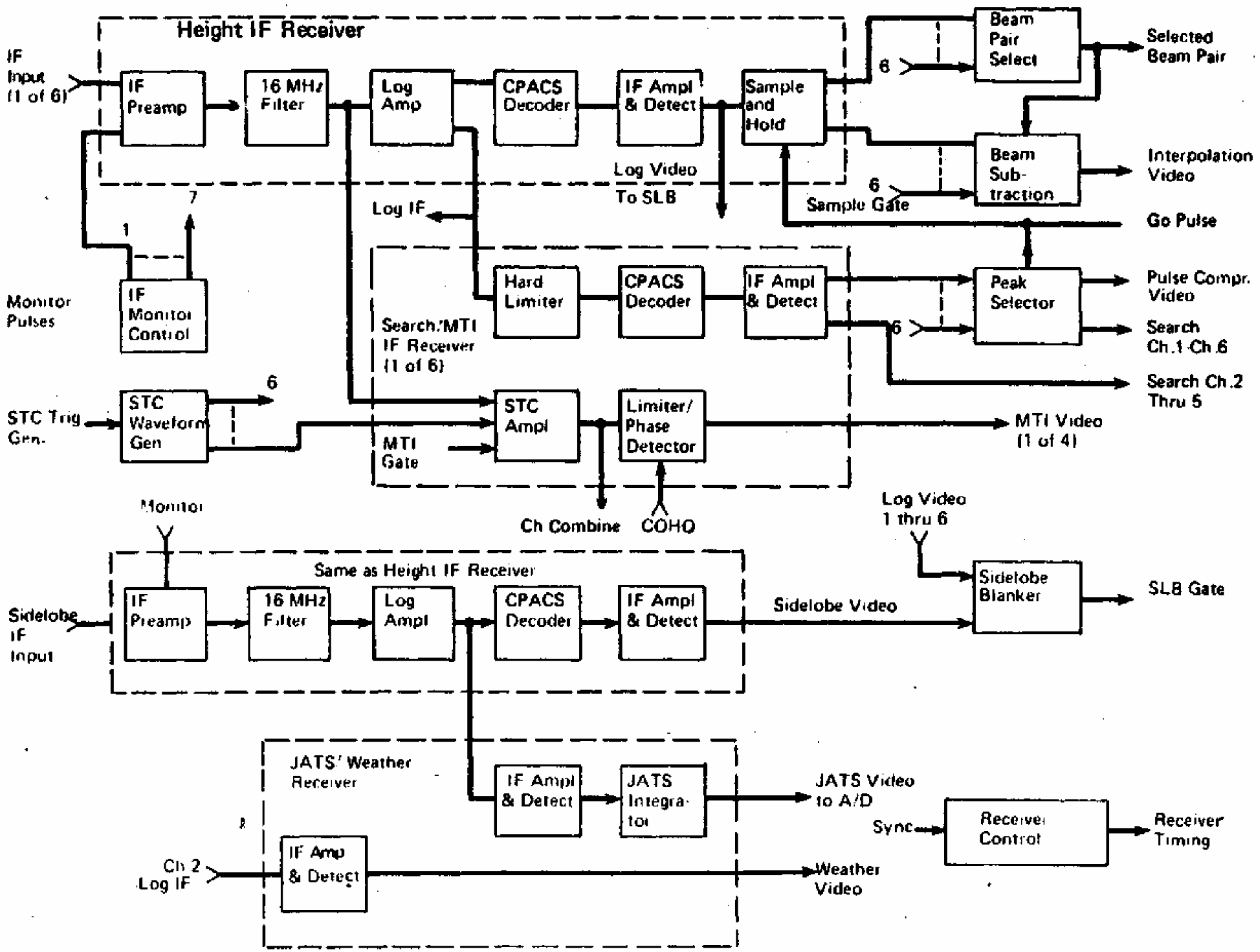
S75-0245-VC-9

3D COVERAGE

The DAR System provides true 3D Radar Coverage. The overlapping vertical beams as shown in the diagram at the left provide radar detection of the full elevation coverage of the radar for each transmitted pulse.

Competing radars are required to scan their pencil beams up and down in elevation while the antenna rotates in azimuth. Competing radars therefore suffer the disadvantage of obtaining far fewer radar returns on each target making their detection and processing more difficult and less efficient. Since they are required to scan in elevation as well as azimuth they encounter what is called a "Time Management Problem" and are forced to adapt special modes of operation to obtain detection in adverse radar environments such as jamming or severe clutter. The special modes competing radars are forced into include restricting elevation coverage and/or reducing their instrumented range, thereby allowing many targets to escape undetected in what would otherwise be normal radar coverage.

The DAR, on the other hand, provides full-range and full-elevation coverage while maintaining full MTI and ECCM capability. Special clutter mapping circuits enhance the detection process such that only areas of clutter exceeding processed thresholds will require MTI processing while, for the balance of the coverage, normal processing may be used for greater sensitivity.



DAR RECEIVER BLOCK DIAGRAM

80-1104-VA 2

HEIGHT PROCESSING

The IF receiver consists of six height channels (one for each antenna beam), six search channels, four digital MTI channels, one sidelobe reference channel, a JATS channel, and a weather channel. The receiver consists of 20 plug-in printed circuit cards, one digital planar array, and other related circuitry.

The height receiver channels determine which beam pair contains the target and interpolates between the beam centers of that pair to measure the angular difference. As shown in the opposite block diagram, the 30 MHz IF target return is amplified and applied to a matched Gaussian filter to establish receiver bandwidth. Follow- ing the filter the precision logarithmic amplifier establishes the required signal amplitude characteristics for height finding. The CPACS decoder then compresses the coded IF pulse to enhance the signal to noise ratio of the target return. The IF amplifier and detector compensates for decoder insertion losses and operates as a linear envelope detector. The detected video pulses are sampled-and held when a target detection is made in any of the search channels. The beam pair selector sums pairs of adjacent channels producing five pair signals. The beam pair with the largest amplitude is detected by differential comparators and sent to the height computer as the base angle determined by the "crossover" angle of the pair of beams containing the target. The beam subtracter interpolates the angle by which the target is above or below this base angle.

A height computer then processes the interpolation data, which has been quantized, and beam pair selection from the receiver. Multiple radar hits occur on each target as the antenna scans past the target. Therefore, a separate monopulse height computation occurs for each of several hits per target. The multiple hit data is then processed by the height evaluator to eliminate any erroneous data. The final evaluated height is then outputted after the end of target criterion has been met. Each height computation considers the factors of base height above radar horizon, interpolation height from base height, antenna tilt, earth curvature correction, and site elevation.

DAR ECCM FEATURES

FREQUENCY AGILITY

- PULSE TO PULSE
- BURST TO BURST
- JAMMING ANALYSIS AND TRANSMISSION SELECTION (JATS)

CODED PULSE ANTI-CLUTTER SYSTEM

STAGGERED PRF

ANTENNA DISCRIMINATION

SIDELOBE BLANKING

DIGITAL MTI

ECM/WEATHER VIDEO

JAM STROBE REPORTING

ECCM FEATURES

The DAR operates with high efficiency in clutter and interference environments. False alarms, which would otherwise degrade operation of manual or automated air surveillance and control systems, are reduced. Electronic Counter-Counter Measures (ECCM) include all techniques which work to defeat the effects of active as well as passive (chaff) jamming and the effects of clutter. ECCM features of DAR include:

- Frequency agility. Any of 16 frequencies across the 200 mhz operating band may be randomly selected on a pulse-to-pulse basis or in groups of pulses.

- Coded Pulse Anti-Clutter System (CPACS) . A phase coded *>. 5 microsecond pulse is transmitted. Upon reception it is decoded and compressed to .5 microseconds. Detection thus depends on the signal having the proper phase code. High resolution is achieved with minimum false alarms due to noise or CW jamming and distributed clutter (chaff, weather).

- Jamming Analysis Transmission Selection (JATS). During each transmission interval JATS operates by sampling the power being received on each of the 16 frequencies in the operating band, then making a comparison to find the frequency with the least jamming. This frequency is then automatically selected for the next transmission.

- Staggered PRF. Staggering the pulse repetition frequency, averaging 250-275 pulses per second, is useful for improved MTI detection. With CPACS and frequency agility it is nearly impossible for an ECM aircraft to simulate false targets at closer ranges.

- Antenna discrimination. The six narrow, stacked beams, each with its own receiver and processor, gives the DAR both azimuth and elevation discrimination against jammers.

- Sidelobe blanking. Using a small reference antenna and receiver, signals received by the sidelobes are blanked before they reach the radar output.

- Digital MTT. ^-pulse cancellers processing I and Q data for each beam (beams 3 and 5 also 4 and 6 are combined) provide discrimination against very short pulse interference as well as elimination of ground clutter at all ranges.

- ECM/weather video. A separate JATS/weather receiver provides a video output, derived from the channel 2 height receiver log IF before CPACS detection. This video is displayed for presence of weather and jamming.

- Jam Strobe. A jam strobe report is developed in the digital target extractor from the jamming detected in the JATS/weather receiver. A second jam strobe circuit produces an outline for display which shows the approximate degradation in detection range caused by jamming.

FREQUENCY AGILITY

RANDOM FREQUENCY AGILITY

PULSE TO PULSE

SELECTION OF FIXED OPERATING FREQUENCY

RANDOM FREQUENCY AGILITY

PULSE TO PULSE

BURST FOR MTI

BURST FOR MTI

JAMMING ANALYSIS AND TRANSMISSION SELECTION (JATS)

JAMMING ANALYSIS AND TRANSMISSION SELECTION (JATS)

FREQUENCY AGILITY

DAR provides three selectable modes of frequency operation.

Fixed Frequency. Any one of 16 equally spaced frequencies across the 200 MHz band is switch selectable. The radar continues to operate on this frequency until a change is initiated by switch selection.

Random Frequency Agility. The radar is capable of making a random selection of available transmit frequencies on a pulse-to-pulse basis. The operator can manually inhibit any of the 16 frequencies from being selected.

Jamming, Analysis and Transmission Selection (JATS). The radar analyzes the environmental spectrum each pulse repetition period and selects the frequency having the least interference for the next pulse transmission. In this case the operator can also inhibit transmission on one or more of the available frequencies.

Since MTI operation is based on phase comparison of return signals of the same frequency on a pulse to pulse basis it is not possible to change frequency for each transmission and maintain MTI performance.

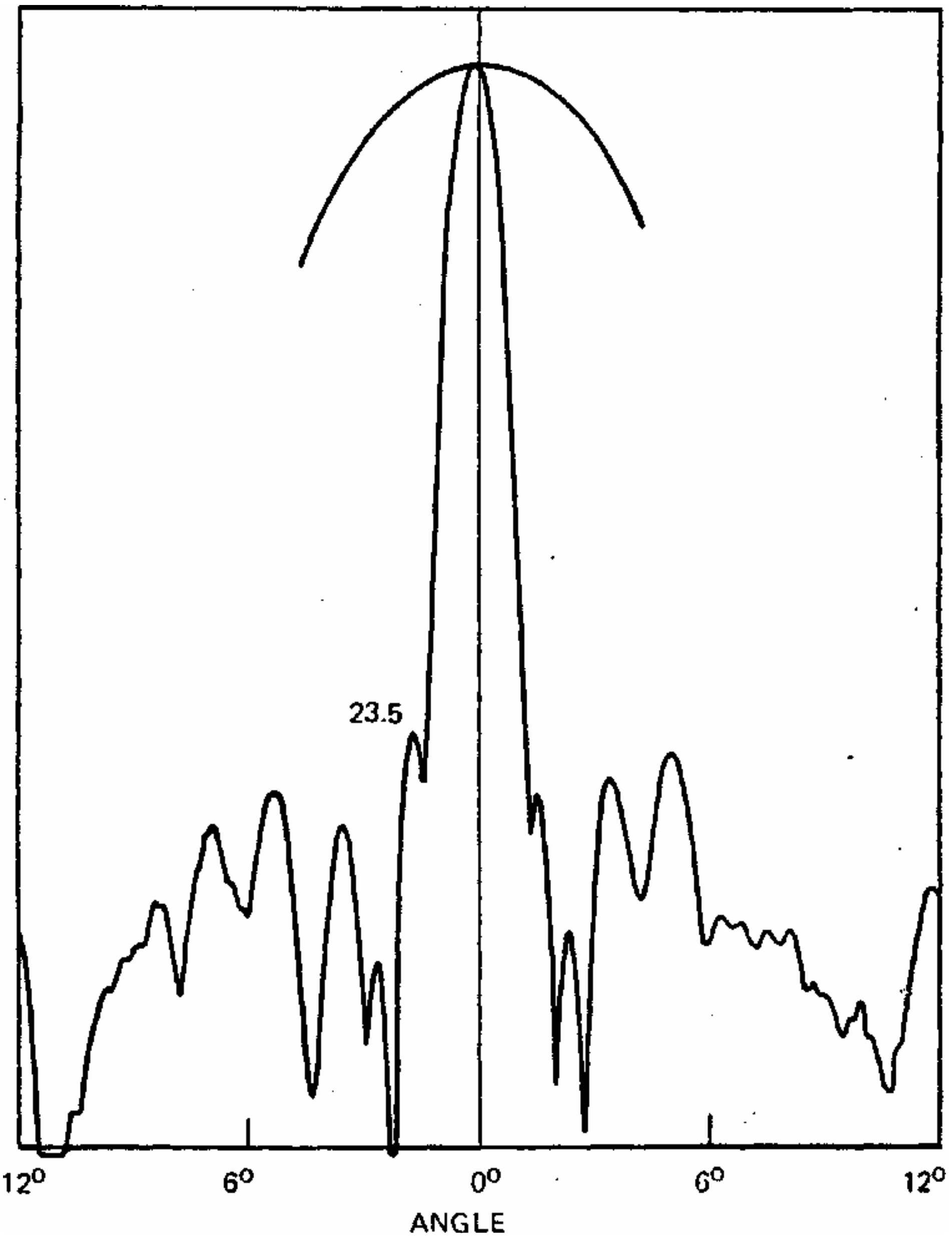
To enable MTI to work with frequency agility DAR provides 12 pulses to be transmitted at the same frequency before switching frequency in either the random frequency agility mode or the JATS modes of operation.

Frequency agility forces jammers to spread their jamming power across the 200 MHz operating band thus lessening their effectiveness to deny target detection.

Typically broadband jammer outputs vary significantly with frequency. Therefore, JATS provides an opportunity to select a frequency for operation at which the jammer is emitting less interferring power.

The Coded Pulse Anti Clutter System, called CPACS was developed by Westinghouse. In DAR the transmit pulse is encoded in the frequency generator and amplified through the driver and final power amplifier. Coding is in the form of a phase reversing 13 bit Barker Code. The echo signal processing provides a constant false alarm rate (CFAR). The processing is a pulse compression which reduces the radar cell size thereby reducing the effects of rain, chaff, and distributed clutter. By rejecting all but the exact code from passing through the receiver, CPACS prevents active jammers from overloading the system. The pulse phase coding also works to permit the radar to transmit a wide pulse and maintain high average power and maintain a small cell size since pulse compression is accomplished in the receiver processing.

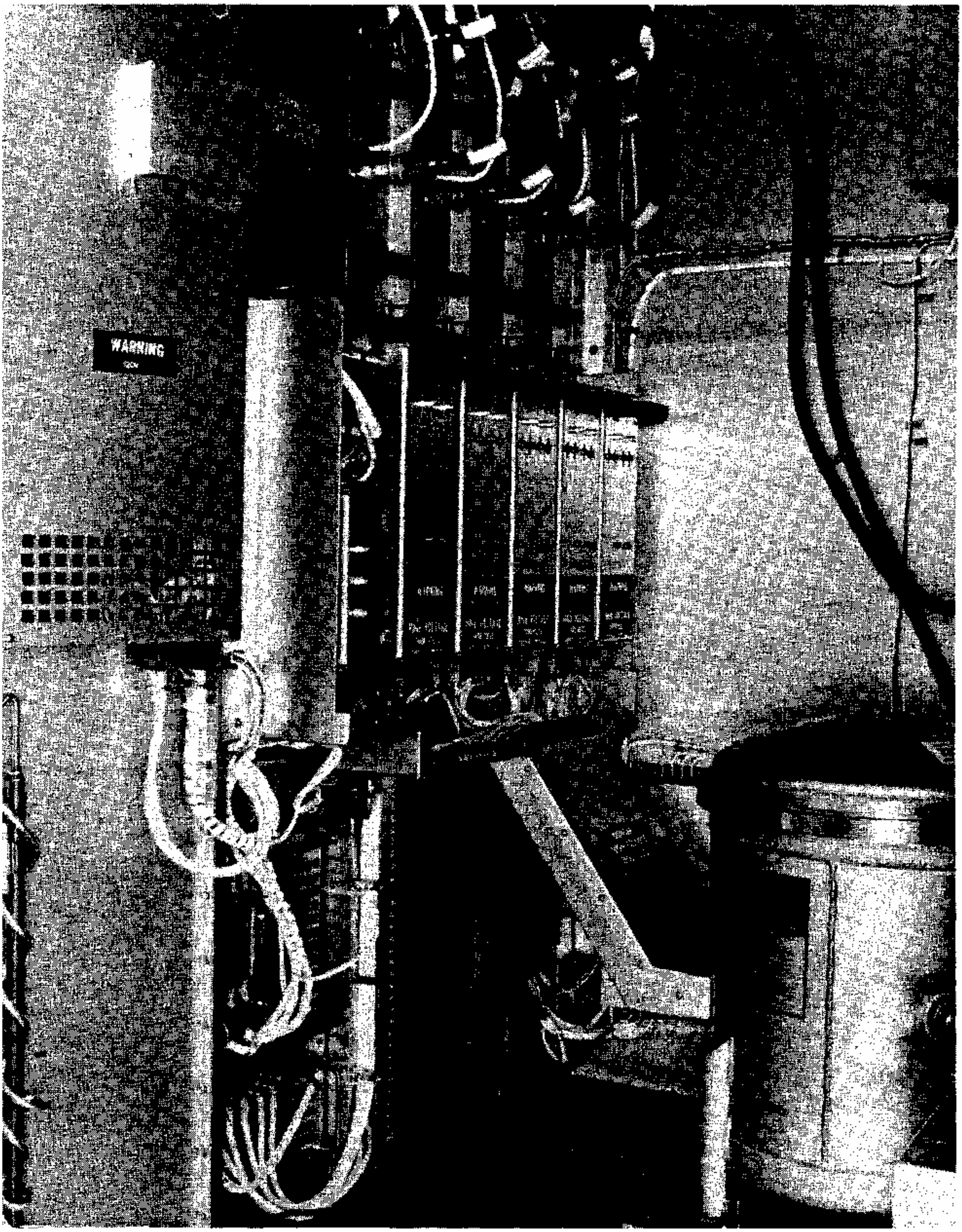
SIDELOBE BLANKING 80-1104-VA-3



SIOELOBE BLANKING

The BAR is implemented with a sidelobe reference antenna and receiver to minimize the detection of targets in the radar antenna sidelobes. The sidelobe reference antenna pattern coverage encompasses the sidelobe structure covered by the radar. The sidelobe blanking channel is fed from the reference antenna and utilizes identical circuitry as the height channels. The sidelobe video pulse is compared with the six height log videos from the height receiver. A detection from the sidelobe blanking channel will cause inhibition of radar video output in the unit signal processor as follows:

> 100% of returns in sidelobes that are at least 10db down and not more than 20db down from the peak of the corresponding main beam,
>
> 98% of returns in sidelobes that are between 20 to 30db down, and
>
> 50% of returns in sidelobes that are below 40db. This ECCM capability is particularly useful when very strong jamming is received since this may be detected over a wide azimuth sector. Sidelobe blanking not only minimizes fake information, but allows the true azimuth of the jammer to be measured by the jam strobe circuit.



IMPROVED SOLID-STATE TRANSMITTER

(SOLID-STATE MODULATOR AREA SHOWN)

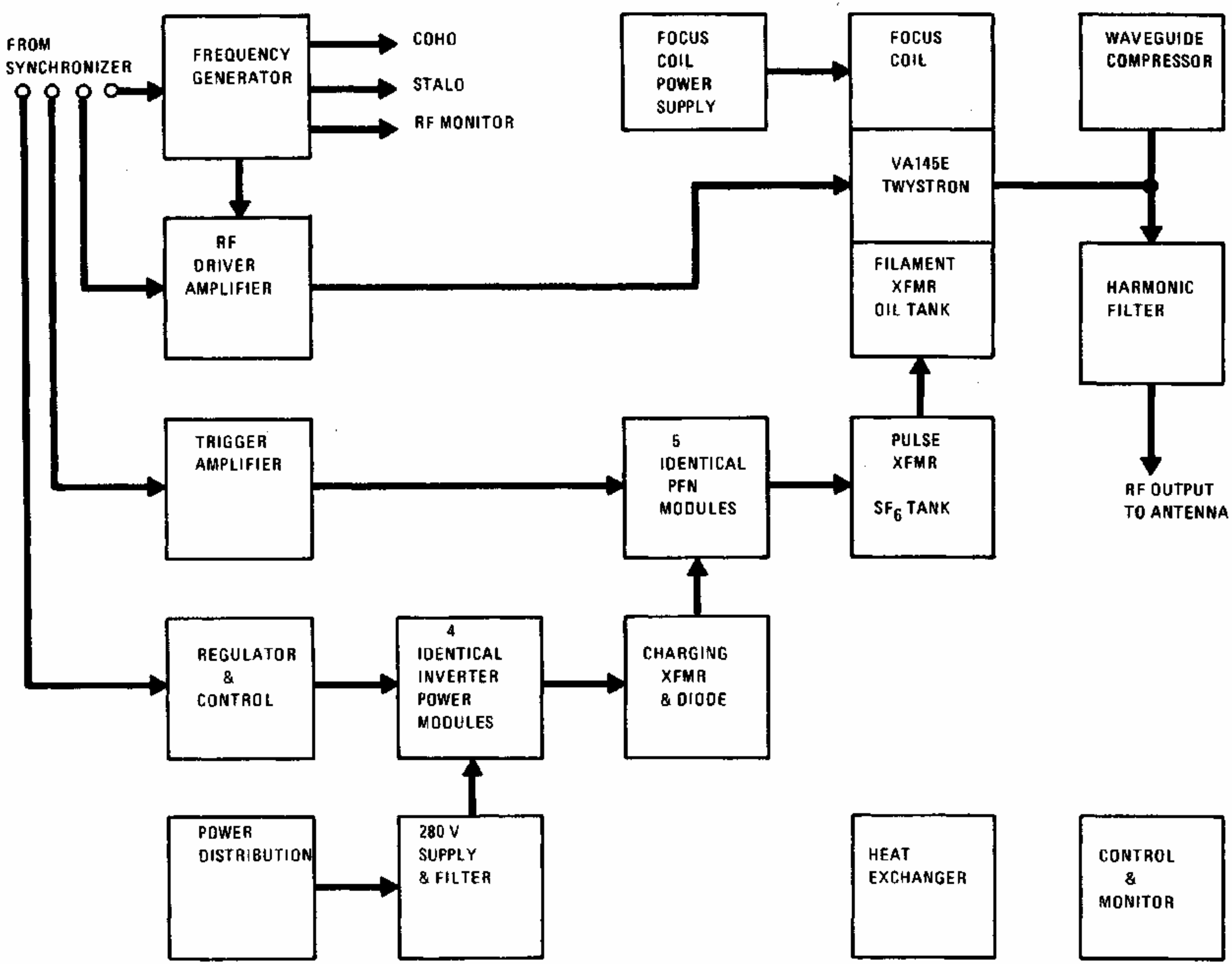
TRANSMITTER

The photograph on the left shows the solid state modulator of the DAR transmitter. The 4 charging inverter modules are in the top row on the left. Just below are the five PFN modules with the trigger amplifier appearing as a sixth module on the near end. The tank contains the high voltage pulse transformer. To the left is the control panel in the "swing out" position.

To the right in the photograph is the RF portion of the final power amplifier. This includes the twystron, waveguide couplers, and a waveguide filter. The twystron is mounted on an oil filled socket tank.

Transmitter Characteristics

Type	Pulsed broadband coherent amplifier
Frequency Range	2.9 to 3.1 Ghz
Peak Power	3.0 megawatts
Average Power	4.9 kilowatts
Duty Cycle	.00179
Pulse Length	6.5 microseconds
Pulse Repetition Frequency	245/250/275 pulses per scan/(average) (fixed or staggered)


FROM SYNCHRONIZER
FREQUENCY GENERATOR
COHO
STALO
RF MONITOR
FOCUS COIL POWER SUPPLY
FOCUS COIL
VA145E TWYSTRON
FILAMENT XFMR OIL TANK
WAVEGUIDE COMPRESSOR
HARMONIC FILTER
RF OUTPUT TO ANTENNA
RF DRIVER AMPLIFIER
TRIGGER AMPLIFIER
5 IDENTICAL PFN MODULES
PULSE XFMR SF_6 TANK
REGULATOR & CONTROL
4 IDENTICAL INVERTER POWER MODULES
CHARGING XFMR & DIODE
POWER DISTRIBUTION
280 V SUPPLY & FILTER
HEAT EXCHANGER
CONTROL & MONITOR

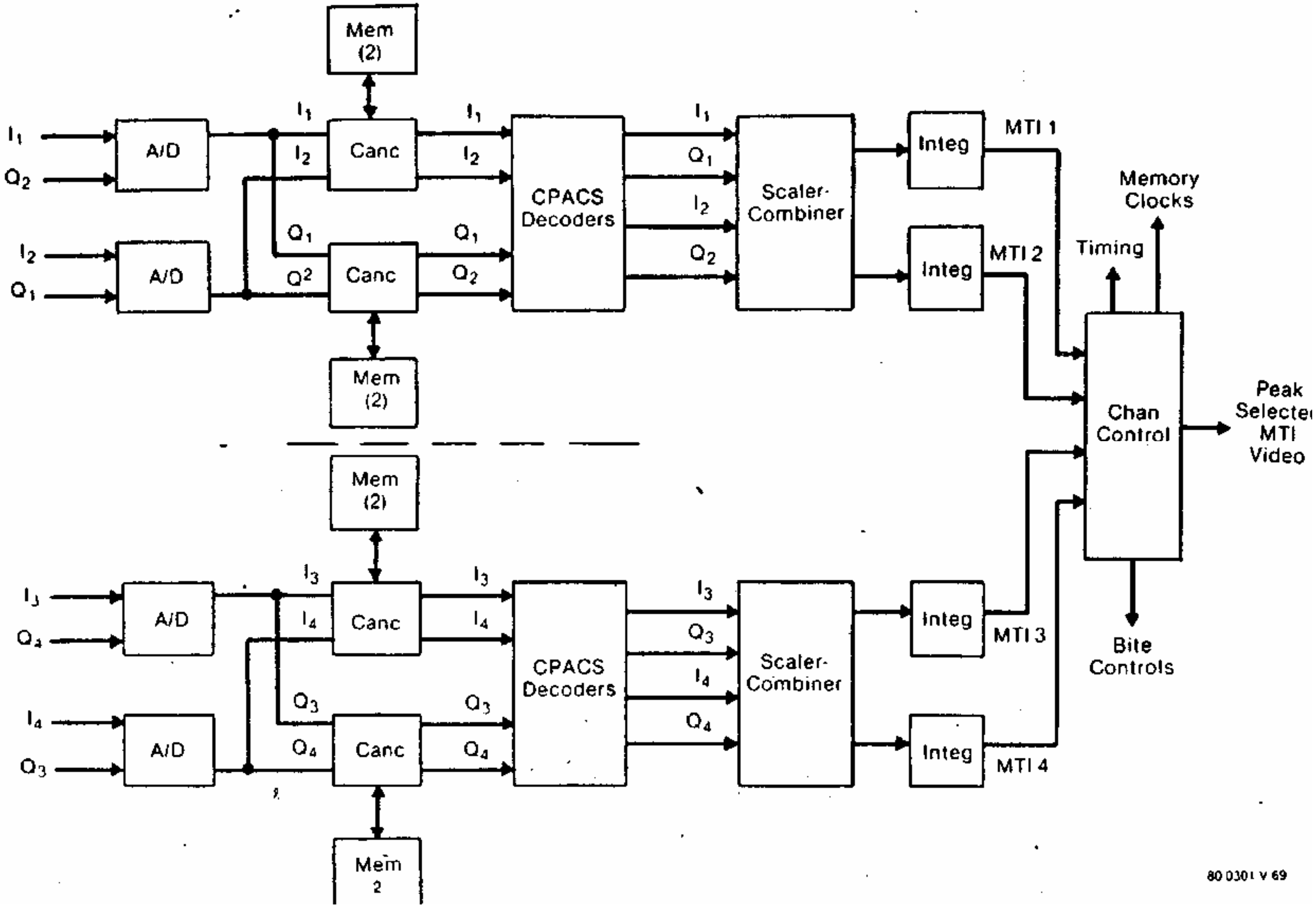
TRANSMITTER

The transmitter equipment, shown in the block diagram, utilizes a completely solid state power supply and modulator subsystem to pulse a VA145E Twystron final amplifier. This final amplifier is driven by a TWT driver which receives a phase coded RF pulse from the frequency generator which also provides the STALO, COHO, and RF monitor signals. The main power portion of .the transmitter contains a 280 V raw DC supply derived from direct rectification of the 3 phase prime power input. This DC level is filtered and feeds an energy storage capacitor bank. Four inverter charging modules are operated in parallel from the capacitor storage bank. The capability of the modules is such that transmitter operation can be maintained with one inverter module removed. The inverter system is a half bridge SCR type, which operates at 10 KHz. Charging of the pulse forming network capacitance is accomplished in two stages. The inverter power output charges the network in 50-100 volt steps to a voltage level that is approximately 100 volts less than the final voltage. Control sensors then shut off all but one inverter module so that the charge cycle is completed in 20 V steps. The charging cycle ends with a slight overcharge on the PFN's which is bled off by a regulator to within 0.05% on a pulse-to-pulse basis. This accurate charging insures the pulse-to-pulse phase stability required for high performance MTI.

The modulator is made possible by the reverse blocking diode thyristor (RBDT), a thyristor type solid-state switch developed by Westinghouse for high power pulse switching applications. The modulator is a line-type system using five identical modules. Each module contains a pulse forming network (PFN) and an RBDT switch assembly.

The five PFN modules are operated in parallel with the switches operated simultaneously to discharge the five PFN's to generate the required twystron operating pulse. The five modules together provide a substantial video pulse power margin so that transmitter operation may be continued with one module removed.

Basic MTI Architecture



MTI PROCESSING

Four separate I&Q digital MTI processors give MTI detection over the entire elevation and range coverage volume of the radar. The MTI processing is in parallel with other signal processing; therefore, it is available at all times. MTI does not require a separate mode of operation. For example, the display areas selected for non-MTI or MTI can be manually selected by the operator through the range azimuth gating (RAG) unit or the MTI can be selected automatically by the clutter mapper circuitry. Remaining areas of the display will be non-MTI.

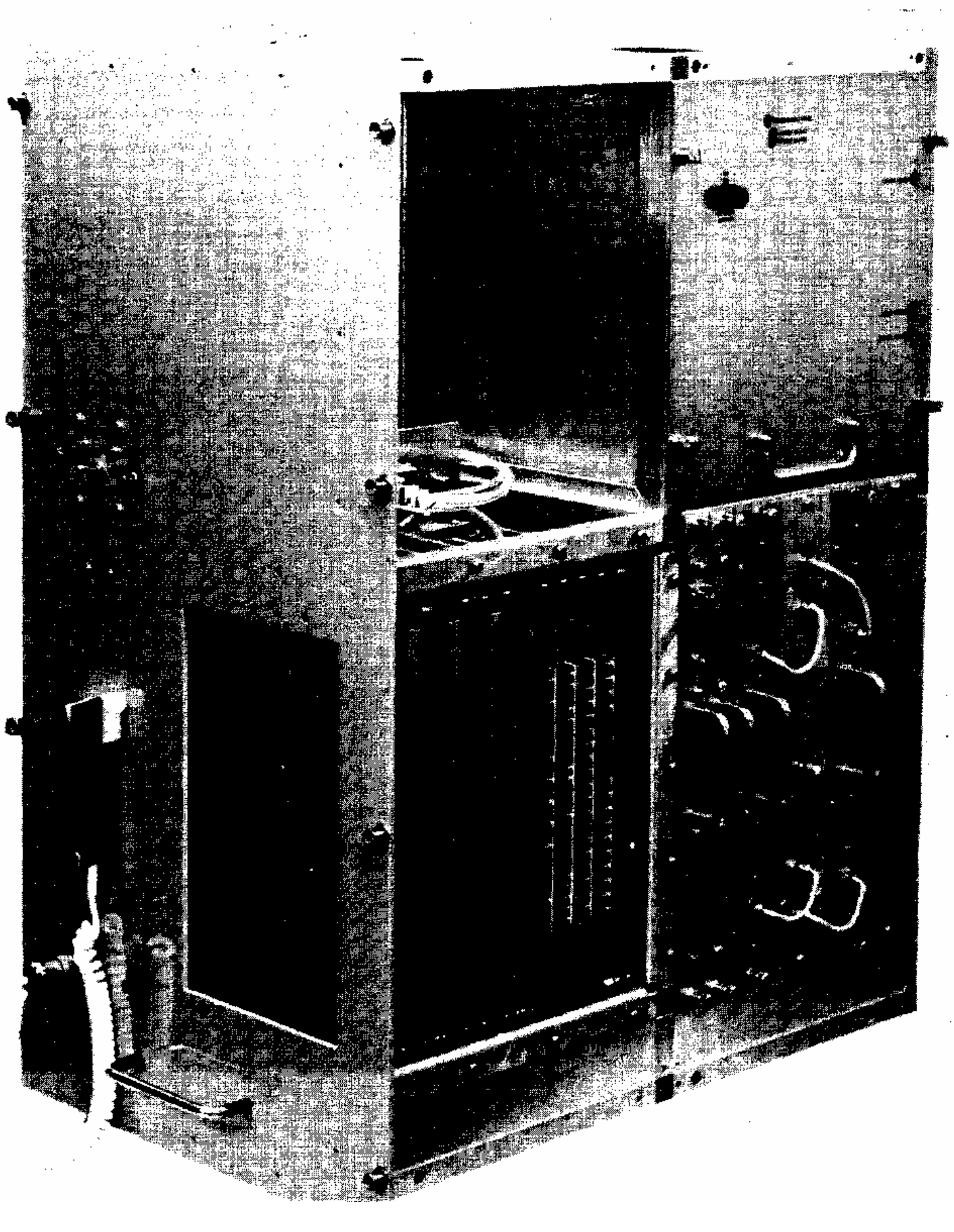
Separate processors are installed in the two lowest beams to preserve the best possible detection in clutter. The higher beams, normally above the heavy clutter, are combined; i.e. beam 3 with 5 and beam 4 with 6, to allow separate processing with fewer circuits.

Each canceller is preceded by 10 bit A/D conversion with the two least significant bits into receiver noise. The MTI improvement factor measures greater than 40 db based on the following parameters:

VIP and scan modulation	44 db
Radar stability	45 db
Dynamic range	SI db
MTI improvement	>40 db

I&Q processing insures good sensitivity for MTI. All digital design provides highly stable operation with few adjustments required and simple initial alignment.

DAR SOLID STATE IFF/SIF UNIT



IFF/SIF SYSTEM

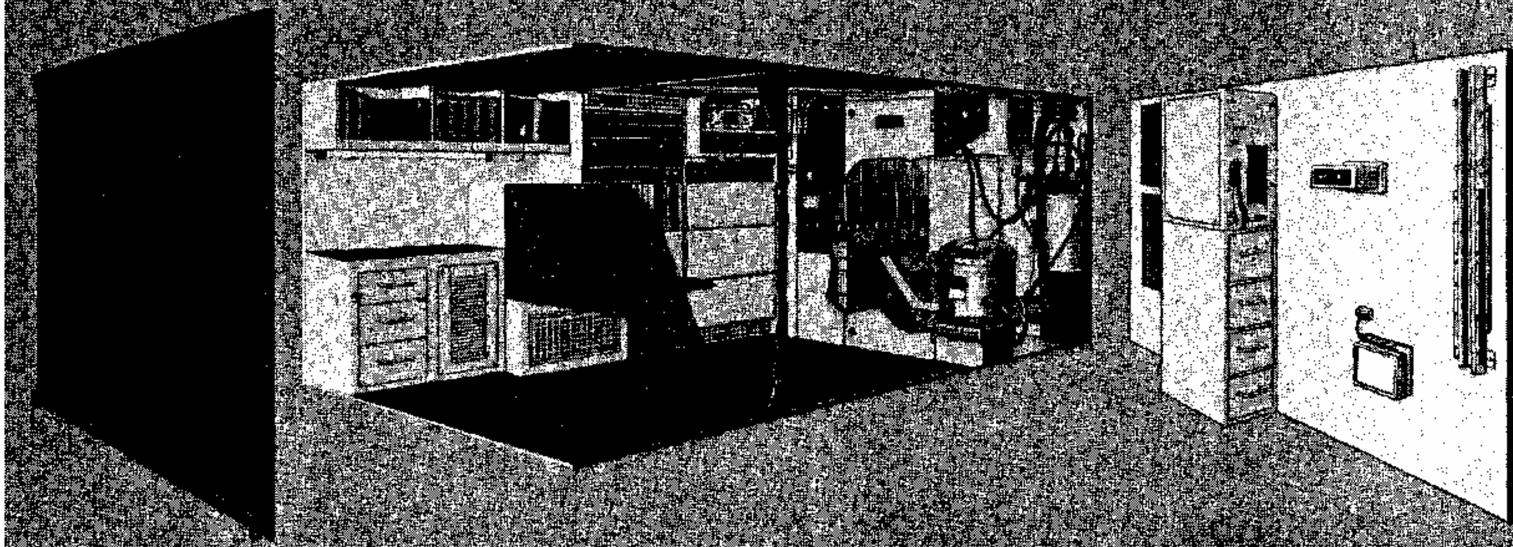
The Westinghouse developed solid state IFF/SIF (SSIFF) subsystem is provided in the DAR. It is mounted within the shelter and connected to the AS-2787 sum-difference antenna which is an integral part of the radar antenna subassembly. The significant advantages of this SSIFF unit are improved reliability, calculated to be greater than 3100 hours, and improved maintainability with an MTTR of 12 minutes. Built-in test equipment (BITE) eliminates the need of external field support test equipment.

The SSIFF unit is designed to operate in Mark X/SIF modes. Functionally, it consists of an interrogator, defruiter, antenna switch driver for sidelobe suppression, and internal trigger source. Video ouput and trigger drivers are provided for routing output signals to the DTE or remote operation centers. Control, mode select, etc. can be exercised from a front panel or from a remote center.

Modular construction consisting of plug-in PC boards, wire wrapped digital boards, and hybrid microwave modules, are used throughout. The control panel is also a plug-in solid state module. Failure indication is by light emitting diode on each module with a fault summary indicator on the control panel. Insertion of commands through the control panel is by a hand-held, coded IR-gun.

A key high reliability component is the 2 kw solid state transmitter. A high voltage (3000 volt) power supply used in older systems has been replaced by a S0 volt supply in the SSIFF unit.

Modular Layout in DAR Shelter



BASIC, SINGLE PPI LAYOUT

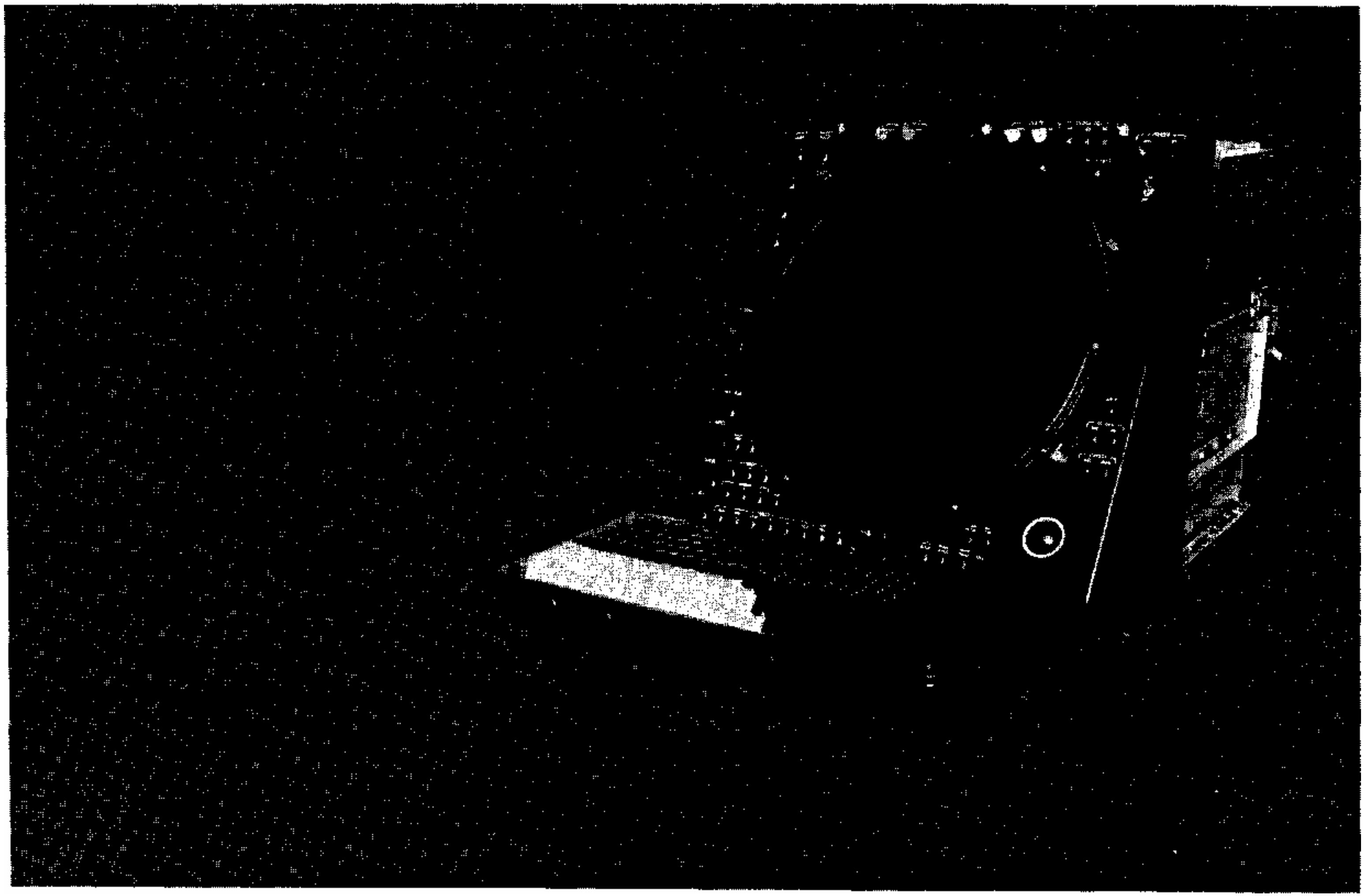
CONFIGURATION

The layout shown on the opposite page is the basic configuration of the interior of the radar shelter used in one version of the DAR. This particular layout indicates only one operator PPI position with additional area used for maintenance/storage purposes.

Other configurations of the DAR include, at the operator area, upper and lower sloping consoles housing two PPI displays, UPA-59B IFF/SIF decoders, digital height read-outs (DHRO's), plus HF, VHF, and UHF radio combinations, comms switching panels, telephones, and related control heads.

Other optional equipment, which can be located below the SSIFF include a Modem assembly, with 3 x 2400 baud capacity, and a Digital Video Mapper to provide mapping and additional editing (alpha-numeric) data for the PPI's.

The aggregate of the expansion capability in the DAR is such that the single shelter can stand as a fully autonomous GCI/surveillance group with full remoting capacity to Sector Operations Centers (SOC's).



AN/UYQ-27(V) Digital Display

DISPLAY

The DAR uses the AN/UYQ-27(V)2 RAPPI display for the presentation of both analog and alpha-numeric (digital) data. A keyboard is added if computer interface is also desired.

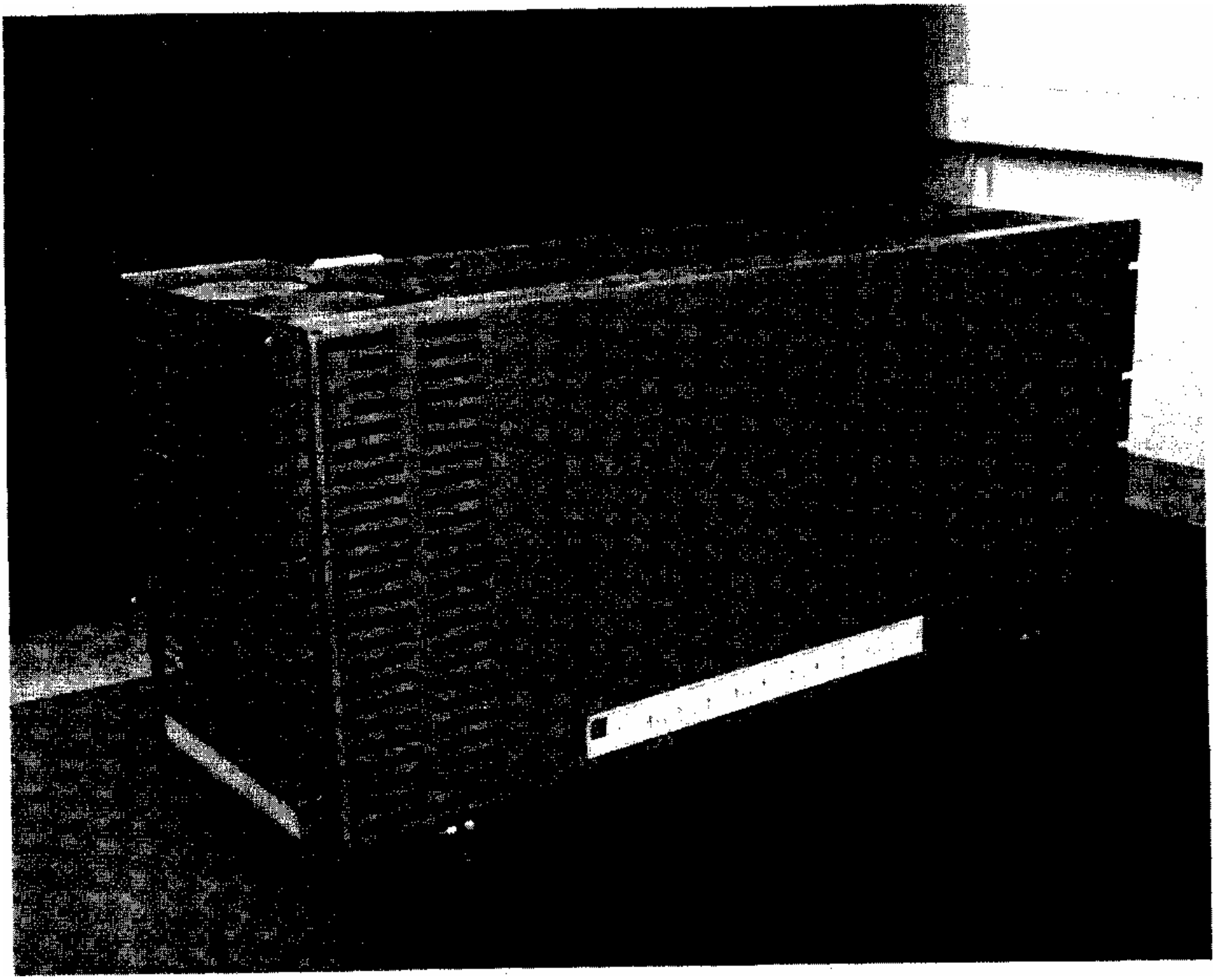
Derived from the AN/UPA-62C display, the AN/UYQ-27(V)2 is the latest in a series of Westinghouse-developed displays. Using off-the-shelf components, this state-of-the-art display has the following features:

Digital solid-state-design, with 16 inch dia. PPI tube
Microprocesser control
Internal symbol and vector generator
Radar and computer interface
On-line performance monitoring
Maintenance built-in-test
MTBF exceeding 3000 hours
MTTR less than 30 minutes

The display is programmed to operate as a standard plan position indicator (PPI) , random access plan position indicator (RAPPI) or in a combination of these two modes. Alphanumeric data, symbols and vectors contained in the RAPPI mode are displayed with the PPI presentation during system dead time in the combined mode.

This general purpose display, shown on the opposite page, is self-contained, solid state, and digitally implemented. Its large display area combined with small volume and light width makes the display ideally suited to a tactical environment, or for semipermanent installations.

DAR DIGITAL TARGET EXTRACTOR (DTE)



DTE ASSEMBLY

THE DIGITAL TARGET EXTRACTOR (DTE) IS HOUSED IN ONE CARD ASSEMBLY (SHOWN ABOVE) WHICH MOUNTS WITHIN THE UNIT SIGNAL PROCESSOR RACK OF THE DAR RADAR. .

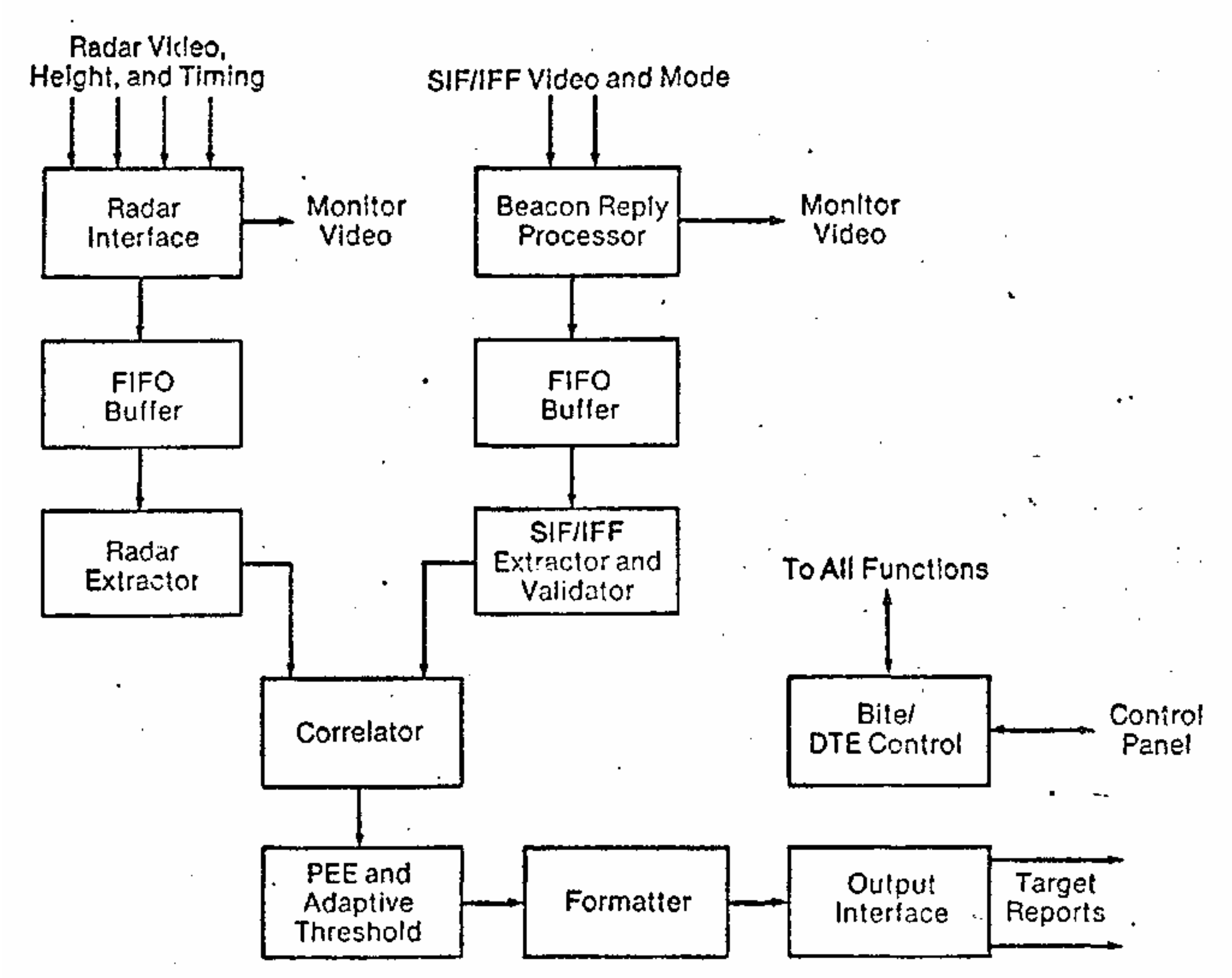
DIGITAL TARGET EXTRACTOR (DTE)

The digital target extractor (DTE) is a high speed and high resolution digital processor which receives 3D digital search radar data and IFF/SIF (beacon) video, code, and mode data. The hit-by-hit data is processed in the DTE to measure the position of each search and beacon target. The separate target extractions are then correlated if the search and beacon data are returns from the same target. Either a composite, correlated target report is formatted for transmission to user terminals or, if uncorrelated, separate search and beacon reports are transmitted. Beacon bracket video is also available for transmission with other radar analog data. The digital reports contain all the target data, including height data, and become the principal interface with command and control centers (e.g. AN/TSQ-73) or other users (e.g. weapon acquisition centers). The format of digital target reports is programmable and easily adaptable to user requirements.

The DTE messages are available for modem link to separate operations centers and for direct input to the RAPPI displays via their S-311 high speed serial channels. Each message consists of the following:

Radar range, bearing, and target strength
Radar height
IFF (Beacon) mode, code, and Mode C height (if selected), and special tags
Status tags

The status tags identify the sources of information, which include radar, IFF, test target, strobe, and equipment conditions data. The IFF information can be sourced from as many as four modes (1,2,3A and C). The IFF tags show if code information was validated, if any emergency existed, and include the X and SPI bits.



ASP/DTE FUNTIONAL BLOCK DIAGRAM

DTE FUNCTIONS

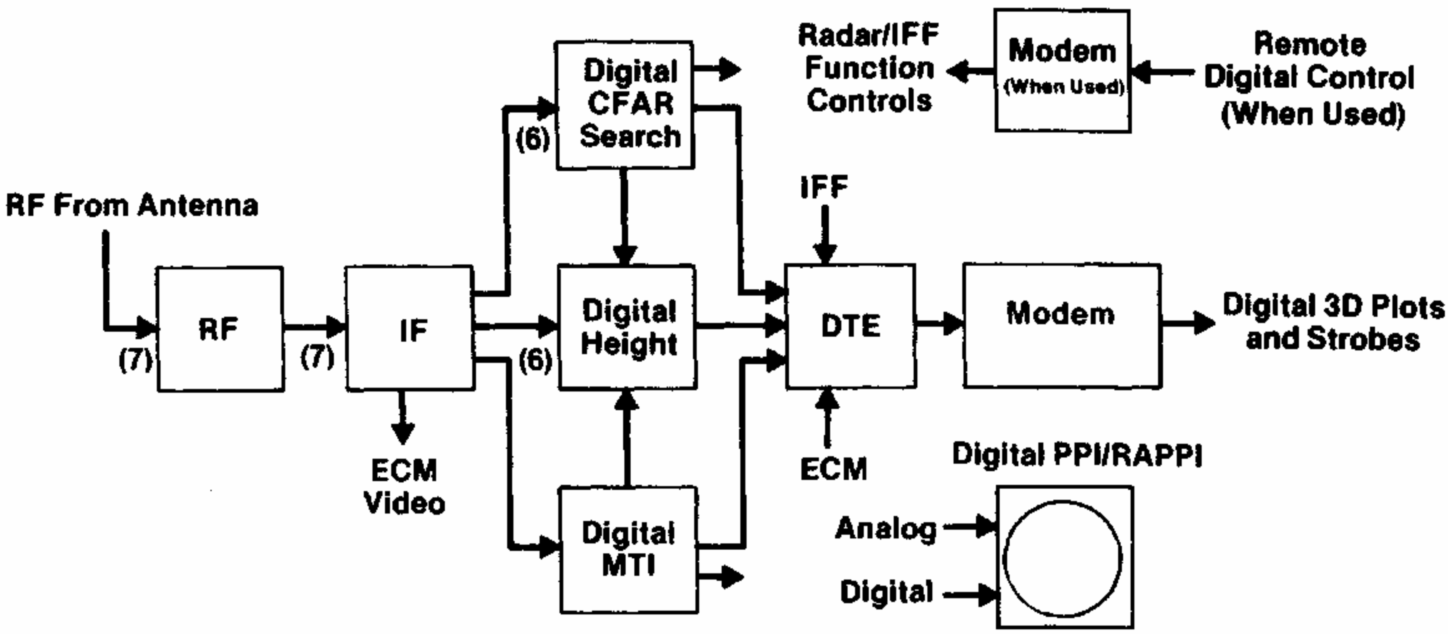
The DTE has been designed to operate at high speed to handle a large target capacity. Radar target extraction uses search or MTI detections as automatically selected by the clutter mapper. Absolute velocity filtering is available to delete fixed and slow moving target reports. Beacon data processing validates IFF returns to prevent false reports. Either serial or parallel digital outputs can be provided with a modulation rate up to 19.2 kbs. BITE circuitry automatically inserts radar and beacon test targets and monitors the response of the various subassemblies.

The functional diagram on the opposite page illustrates the operation of the DTE. These functions include:

- Centroiding of radar (search) returns
- Centroiding of beacon returns
- Beacon code processing and validation
- Beacon EMERG & SPl code processing
- Correlation of search, height and beacon reports
- Jam strobe processing
- Permanent echo elimination/absolute velocity filtering
- Adaptive threshold limiting
- Message formatting and buffering
- Status message reporting
- BITE, fault isolation
- Communication links (modem, landline)

The DTE provides a reporting message the accuracy of which corresponds to the radar signal processor output and at virtual real time.

DAR Signal and Data Flow



SYSTEM CAPABILITIES

Output data from the DAR consists of digital and analog target information which can be transmitted to command centers over land lines or microwave links. Digital data in the form of target reports are formatted in accordance with user interface requirements and transmitted at selectable modulation rates. These reports include:

> Range, azimuth, and height IFF (beacon) mode,
> code, SP1, and EMERG Mode C height (when
> provided by aircraft) Correlation between
> radar and beacon reports

Analog data consists of MTI/normal video, selectable monitor video, weather/ECM video, IFF bracket video, and zero range and timing triggers and azimuth data.

DAR data may be used in a variety of functions which include:

> early warning for air defense
> surveillance/GCI operations
> command center system remoting capabilities
> target correlation with airborne command and control systems
> enhancement of air space management through 3-D capability

The quality of DAR data is such that it can be used by fire control units in lieu of their own acquisition data.

Under development in Westinghouse for the U.S. Air Force application is an advanced tracking system. Target track and prediction data will be computed in the DTE tracker and transmitted in lieu of position reports. This additional information minimizes false target reports and shortens engagement reaction times.

DAR CHARACTERISTICS

System Performance	
Coverage	
Range	2 to 440 km
Elevation	0 to 20 degrees
Height	radar horizon to 30,500 km
Azimuth	360 degs continuous
Detection	325 km, 2.5 sq. m. Pd = .8, Pfa = 10^{-6} 20-2000 kts.
Accuracy	
Range (1 sig.)	154 m. .25
Azimuth (1 sig.)	deg.
Height	2 m. to 185 km
Resolution	
Range	154 m.
Azimuth	1.5 deg.
Data rate	10 sees.
Emplacement time (5 men)	1 hour 1/2
March order time (6 men)	hour
MTBF	400 hours
MTTR	30 minutes
Radar Parameters	
Transmitter	
Type	coherent power amplifier (VA145E Twystron) 2.9 to 3.1 GHz 1"S
Operating band Frequencies	selectable pulse to pulse agility, random, JATS 12 pulse sequence for MTI
	<S.5 usecs.
Pulse width	13 bit phase code
Pulse coding	
Pulse repetition	245/250/275 Hz 7
Nominal	pulse sequence
Stagger Peak	3.0 MW nominal
power Average	4.9 KW
power	
Primary power required	
	120/208 volts, 3 phase, 4 wire
Voltage	400 Hz
Frequency	<S0 KW, 73 KVA, PF 0.85
Total power	

DAR CHARACTERISTICS

Antenna	
Size	5.2m x 4 .27 m
Gain	
Transmit	37dB
Receive	41dB
Polarization	vertical
Beamwidth	
Azimuth	1.1 deg.
Elev.	1.5 to 8.1 deg. (six stacked beams for 20 deg. total coverage)
Scan rate	6 rpm
Tilt	-1.5 deg. to +3 deg.
Noise figure	3.5dB
Sensitivity (MDS)	-105dbm
IF frequency	30Mhz
Interference rejection features	CFAR, sidelobe blanking, JATS, frequency agility, coherent digital MTI, elevation discrimination, CPACS, staggered PRF, sector blanking image rejection filtering, video integration
Transport characteristics	
Antenna Shelter	3.73m x 2.23m x 2.29m, 2000 kg 4.5m x 2.21m x 2.13m, 3200 kg
Environmental characteristics	
Ambient temperature	
Operating	-40 deg C to 52 deg C
Non-operating	-62 deg C to 71 deg C, up to 180 days
Wind	
Operating Non-oprating	9fi km per hour 170 km per hour
Relative humidity	95%
Barometric pressure	
Operating Non-operating	sea level to 3,050m sea level to 15,250m

DAR HAS 30 MINUTE MTTR

Built-in Test (RP/IF/Digital)

On-1ine

Off-line

Built-in Fault Indicators Remote

Summary Fault Indication Built-in Test

Equipment Functional Partitionikng of

Equipment Improved Accessability Plug-

In Replacement Reduced Spares

MONITORING

DAR contains a built-in monitor oscilloscope, monitor control panels for major assemblies (transmitter, receiver/processor, DTE, and solid state IFF system), PC board fault lights, and summary fault lights for assemblies. The monotor oscilloscope includes probes for displaying waveforms available on any test point in the radar shelter. Rotary switches provide inputs to the oscilloscope and monitor meters. Automatic and manual fault tests are available to assure proper functioning of all assemblies and to assure that major performance parameters are within specification. The frequency generator supplies four montor pulses at IF for log slope monitoring of each channel including the sidelobe blanking receiver. It also provides one phase coded RF monitor pulse to be used in the receiver/processor system for gain balance, alignment, and minimum detectable signal (MDS) measurements. The signals are inserted in the "dead" time of the radar and, after processing, are viewed at the monitor oscilloscope. In addition to monitoring receiver functions, height channel calibration is accomplished by use of the relative amplitude between the four IF monitor pulses and accurately observing the relative output on the oscilloscope. Calibration such as this is performed only at infrequent intervals, while monitoring is done at any time without interruption of normal operation.

By using a "live time" real-time quality control (RTQC) radar and beacon (IFF) test target, on-line monitoring of all main processing elements in the DTE is performed at least once per scan. A fault detected as result of these BITE tests illuminates a summary fault light on the DTE control panel. This summary fault also includes errors in the output data messages. The status of each DTE plug-in module is indicated by an individual light and a fault is incorporated in the summary fault circuitry.

Automatic on-line and manual built-in-test and fault isolation to the module level is provided in the solid state IFF system. Separate test equipment is not required. A summary fault indication is provided on the front panel of the unit.

Similar fault lights as described above are provided on the PPI.

DAR Is Fully Supported

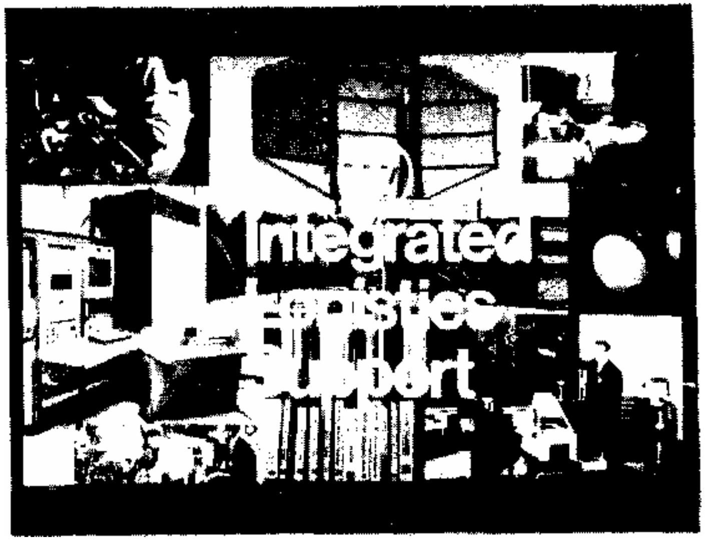
Logistics - Maintenance * Support Concepts
Based on Field Experience

Technical Manuals - Provisioning Data
Developed

Training Programs - U.S. or Europe
Developed

Support Equipment
Developed

Field Engineering Support
Available



INTEGRATED LOGISTICS SUPPORT

DAR is now in production at Westinghouse and a full support package is developed. Logistics and maintenance support concepts are based on field experience. Technical manuals have been written and spares provisioning data developed. Training programs are available and so is special test equipment for depot and field level maintenance.

Westinghouse maintains an Integrated Logistics Support Division with hundreds of employees trained and experienced in the skills necessary to develop and implement effective support programs for Westinghouse equipment and equipment built by others. Our field engineers are stationed throughout the world and are especially trained on the equipments to be maintained. Because of the ongoing DAR Program Westinghouse can provide a very effective support package for DAR without burdening the customer with start up and development costs.

GROWTH POTENTIAL

Considerable effort is currently underway to provide DAR with improved ECCM capabilities to counter the postulated 1990's threat. A prototype Ultra-Low Sidelobe Antenna (ULSA) for the AN/TPS-43 has been built and recently completed testing at the USAF's Rome Air Development Center. Additional testing at Aberdeen Proving Ground and Eglin Air Force Base has been successfully completed. A follow-on contract with ESD-USAF is already underway which will lead to serial production antennas for USAF. Additional AN/TPS-43 ECCM growth potential areas, currently with USAF funding support, include the low cost anti radiation missiles (ARM) Decoys, ARM alert radar and self-screening jammer (SSJ) protection circuitry.

DAR is an excellent choice for military forces requiring mobile 3D Radar. Without question it gives the highest degree of mobility with overall performance which is not surpassed by any other radar. It is a low risk proven approach, it is in current production and is the very latest design. It is fully supportable and because of continued production and deployment of the AN/TPS-43 radar family it is guaranteed ample spare parts at reasonable prices for many years into the future. It has programmed growth and improvement for the future and best of all -it is affordable.