Some Glimpses into Early RADAR In World War Two – Novel, Primitive and Effective

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RADAR,* the U.S. Navy declared in 1940, was the proper term for RAdio Detection And Ranging. World War Two then loomed for the United States. Belligerent powers developed radio-related auxiliaries for weapons, RADAR among them. RADAR pretty much won the war (along with the late addition of the atomic bomb). It was both very new and very simple, albeit effective. RADAR sank many a warship, even in fog and at night, because the early systems could "see" them as their hulls above the waterline made them like corner reflectors. But even submarine periscopes could reflect enough energy to provide a target.

Primitive RADAR detected the Japanese air-fleet about to bomb Pearl Harbor on December 7, 1941. But the Army had not put in place any process to manage that intelligence. Sailors died and ships sank. This taught a hard lesson. To be prepared for war required not only capable equipment but also readiness to implement its powers. The British pioneered these techniques.

Early RADAR sent out radio waves in one direction and sought to display any reflection from any object. The reflections appeared as lines on cathode ray tube screens. Perhaps as early as 1903 or so, such reflections had been detected. Both Marconi and Hugo Gernsback prophesized wireless detection and ranging. Probably the British 25 MHz Chain Home shore-based system (using large curtain-like antennas) first succeeded in detecting enemy aircraft, *circa* 1939 and mapping them for interception. But for Spitfires to shoot them down, or to attack vessels from the air, RADAR on aircraft had to find them first.

* See: https://en.wikipedia.org/wiki/Radar_in_World_War_II

This is what a flying RADAR operator saw:[†]

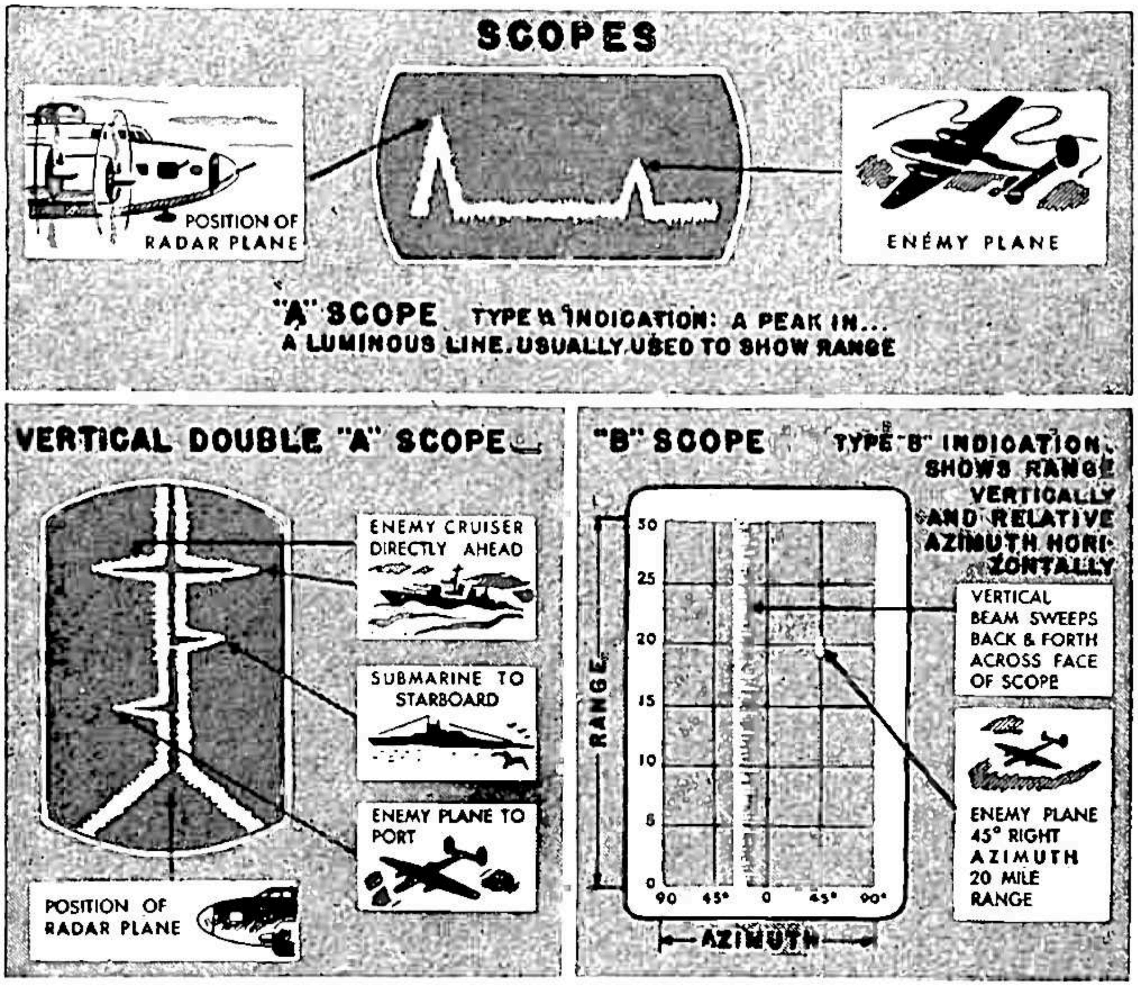
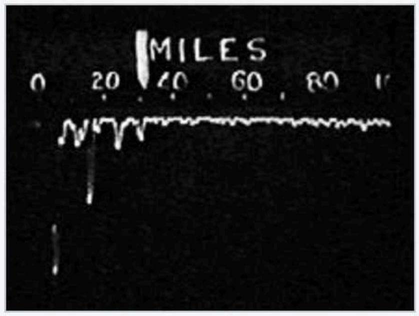


Fig. 2 A, top—Positions of objects shown in the "A" scope. B, center left—Pips on a vertical "double-A" scope. C, center right—A "B" scope, showing the range and azimuth.

With The Double-A scope, the RADAR displayed both surface vessels and aircraft, with a range and a direction (left or right). The B scope provided both precise direction and range.

[†] *Radio-Craft*, Nov. 1945, p. 95. The operator had to vector the pilot into the target.

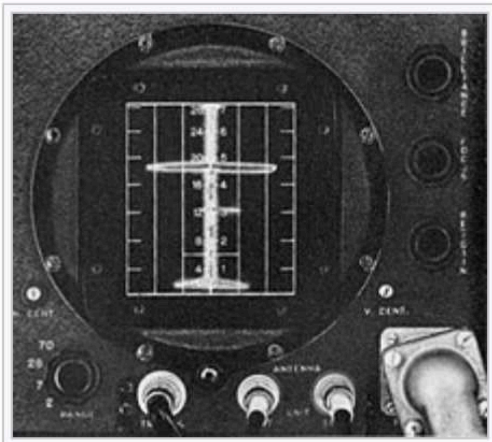
The Chain Home system used an “A”-type display:



Chain Home is the canonical A-scope system. This image shows several target "blips" at ranges between 15 and 30 miles from the station. The large blip on the far left is the leftover signal from the radar's own transmitter; targets in this area could not be seen. The signal is inverted to make measurement simpler.

From the wiki.

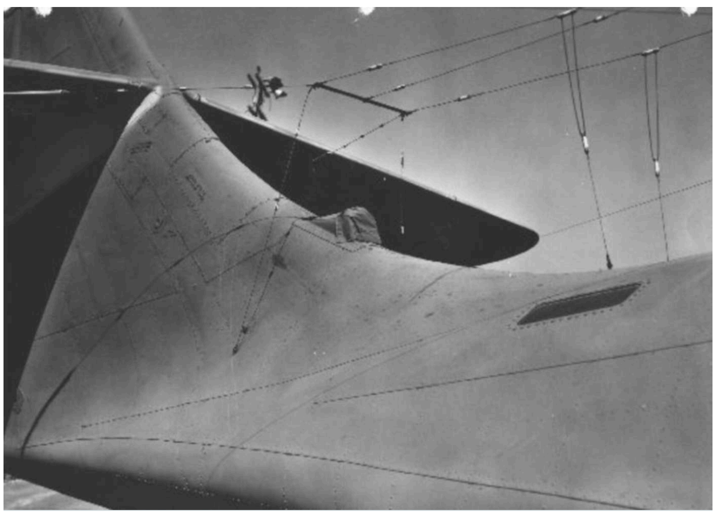
The Double “A” could provide rough directionality to a target:



The L-scope was basically two A-scopes placed side by side and rotated vertically. By comparing the signal strength from two antennas, the rough direction of the blip could be determined. In this case there are two blips, a large one roughly centred and a smaller one far to the right.

From the wiki.

Submarines wreaked havoc on Allied shipping. Finding them wasn't easy. The Germans required their Captains to come up and report every day by radio. The British broke the Enigma cyphers and hence also got the position reports. Still, precise location often required RADAR. In the Pacific theater Japanese submarines took a heavy toll. To meet the threat, the Navy developed side-looking RADAR, after the British. The U.S. PBY recon seaplane aircraft carried it. This is the tail of a PBY with its Sterba search antennas.



Internet sourced.

One RADAR operator described it long afterwards:

"If my memory serves me correctly, the search antenna was a Sterba Array which stretched between the aft section of the wing and the tail emphanage and provided a figure "8" transmit/receive pattern for search, and when a target was acquired, the radioman informed the pilot of the direction (i.e. port or starboard) of the target acquisition ... the pilot reported back to the radioman, "OK, making a turn to Starboard... or Port, ... as required"..... at that time the radioman would shut down the ASB (we used to refer to it as the Baker gear) modulator, manually disconnect the two Sterba Curtain Array coaxial cables from the motor driven mechanical switch, attach the two coaxial cables driving the Port and Starboard Yagi antennas having a relatively forward uni directional mode ... again power up the ASB modulator ... and then with his vertical "A" RADAR display direct the pilot either "right or left" as required to display equal amplitudes of the vertical "A" display " pips ... indicating a "homing in" mode. Long time ago, but as I recall, the maximum range was 80 KM." (http://www.warbirdinformationexchange.org/phpBB3/viewtopic.php?p=524687)

The Sterba curtain array antenna‡ came into use in the 1930s, as a directional gain antenna for shortwave transmissions and broadcasting.

The Sterba curtain array is a chain of identical collinear elements as in the TCI Dipole Array at KNLS, Anchor Point, Alaska. The initial elements are shown here as a center-fed antenna, although it can be fed at other points as well. (Courtesy: World Christian Broadcasting)

From the wiki.

The British figured out that the Sterba Array could provide long-range, wide-range two-sided RADAR from a searching aircraft: ASV = Aircraft, Surface/Search, Vessel. In effect, it made for two radio-searchlights, one to each side of the aircraft.

"… 1939, Hanbury Brown received a request to fit ASV to the Armstrong Whitworth Whitley bomber, which was no longer competitive and was being passed off to other uses. Brown took the chance to develop a new antenna, a type of Sterba array, that stretched along both sides of the flat rear fuselage, firing to the side instead of forward. This "broadside array" allowed the aircraft to

‡ See https://en.wikipedia.org/wiki/Sterba_antenna - invented by Ernest Sterba for Bell Labs about 1930.

search wide areas of the ocean on both sides of the aircraft at the same time, a great improvement over the forward-only design.

“The broadside array offered about 2.5 times the gain of the original system. This allowed it to detect moderate-sized ships at 40 miles (64 km) and surfaced submarines at 10 to 15 miles (16–24 km), an enormous advance over the Mk. I style antennas. The aircraft could scan the approaches to a convoy by flying 10 miles to one side of it, sweeping a 20-mile wide path. Submarines were not fast enough to cross that distance before the aircraft had returned for another sweep. There was some discussion of giving it a special display to make interpretation easier, but it went into service using the original ASV display instead.”
(https://military-history.fandom.com/wiki/ASV_Mark_II_radar)

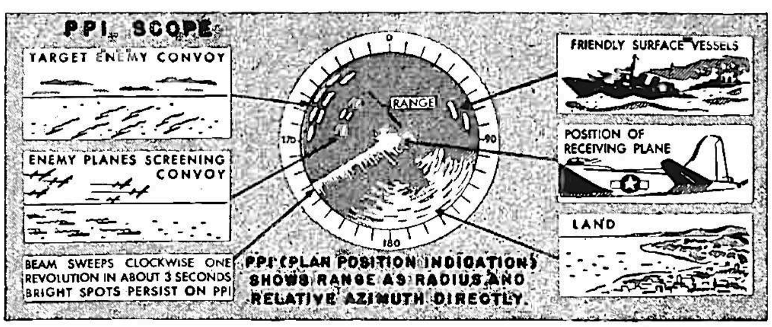
Note Sterba antennas along the side behind the wing of an “obsolete” Armstrong Whitworth Whitley bomber sinking a German submarine (artist’s conception, courtesy of Arden Allen, CHRS, from https://www.scalemates.com/kits/fly-72007-armstrong-whitworth-whitley-gr-mk-vii--142257): “Re-purpose, Re-use, Re-cycle.”

Before the more precise U.S. (Army, Navy] AN/xxx-n nomenclature system, radio and electronic system names derived roughly from use.[§] For example, in the Navy, Search started with "S" as in SG. Fire [gun] Control started with "F" as in FD. "AI" provided the acronym for certain airborne RADARs for interception. For navigation it was AY+. For airborne attack it seems always to have been AS+; *e.g.*, ASB, ASD *etc*. and the third letter may just have been a sequence indicator. ASB was known as "Baker," (as above).

Morgan McMahon summarized some of the development:

> "ASV Mark II, at 176 MHz, saw extensive service against submarines and surface vessels, with good results. With major modifications, it became the British ASE and the U.S. SCR-521. *** ASE's successor was ASB, last of the non-magnetron Allied airborne sets. *** The Navy developed the 3,000 MHz ASG, which became the AN/APS-2… *** The AIA, another small-sized, high-performance radar, was developed for NRL by Sperry…. *** SCR-717 3,000 MHz radar, used for navigation and bombing, was very similar to Navy's ASG (AN/APS-2)."[**]

By the end of the War, 360° Plan Position Indictors (PPI) emerged generally, in connection with rotating antennas, especially on warships.



Radio-Craft, 1945, above.

[§] See https://www.history.navy.mil/content/history/nhhc/research/library/online-reading-room/title-list-alphabetically/u/operational-characteristics-of-radar-classified-by-tactical-application.html

[**] http://www.smecc.org/mcmahon%27s_radars%21.htm (an excellent presentation by Ed Sharpe, CHRS).

The Proximity Fuze[††] distilled RADAR into an anti-aircraft and ground-war artillery shell, which decided for itself when to explode when close enough. This materially advanced victory in World War Two, especially in the Mediterranean theater.

World War Two gave us many technological advances, among them RADAR. Today, everyday, we can see weather RADAR at will, on the Internet or even archaic cable Television. It guides air traffic and vessel traffic, and soon, perhaps, automobiles as well. It can save lives, and it can give us speeding tickets. "Progress is our Most Important Product." And we did win at least that war…

(18 V '22, v2, de K6VK) ##

[††] https://en.wikipedia.org/wiki/Proximity_fuze