

# Development of Radar SCR-270

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During the middle of the prewar decade, a small group of engineers and scientists at Fort Monmouth, New Jersey labored under great secrecy developing a military weapon destined to play a major role in winning a global war.

In the midst of a complacent, peace-loving United States, these pioneers worked in silence, desperately handicapped by lack of funds, facilities and assisting personnel. Driving, ever driving, inexorably striving toward a military objective of utmost importance were a small group of engineers and physicists headed by Maj Gen (then Lt Col) Roger B. Colton, early laboratory director Lt Col William R. Blair, and civilian Chief Engineer (later Lt Col) Paul E. Watson, whose combined inspiring leadership seemed to convert normal engineers and physicists temporarily into composites of Newton, Maxwell and Einstein.

From the efforts of this small Army group, a similar group in the U. S. Navy, in England, and later in the Office of Scientific Research and Development, rose the greatest of all electronic military weapons, the weapon to which victory attached her wings, a device which saluted the atomic bomb, but did not bow to it - the fabulous scientific genie of World War II -- RADAR.

It is the purpose of this article to trace the development of the SCR-270-271 series of Radars. These radars had their origin in the work which preceded and eventually culminated in the first Army radar, Search Light Control Radar SCR-268. In fact, it would be only fair to say that SCR-268 is the original ancestor of all Army and U. S. Air Force radars, it being remembered that the first U. S. Air Force radar

was a modified SCR-268 installed in a B-18 at the Red Bank, New Jersey Airport.

We should mention that both the SCR-268 and SCR-270 series each had many modifications and conversions adapted to specific applications. Thus, one should speak of an SCR-268 family of sets, all of which were mobile, that is, mounted on trucks or trailers. Similarly, the SCR-270 family were mobile sets while the electronically equivalent radars intended for fixed station installation were known as the SCR-271 family of radars.

Development work on the pulse method of radio location at the Signal Corps Laboratories started in the early 1930's. By May 1937 this work had progressed to the point that a historical field demonstration at Fort Monmouth was given for the Secretary of War. The crude equipment performed so well that the Secretary was convinced this new technique offered such great promise that it should be vigorously pursued. There followed then a period of intense development on the embryo SCR-268, intended for and backed by the Coast Artillery Corps. This set had military characteristics calling for a search light controller to position and aim searchlights for spotting aircraft.

Following the May demonstration, the Signal Corps Laboratories reorganized and formed the Radio Position Finding Section, headed by the Chief Engineer, Paul E. Watson. A small staff of approximately five engineers started the Herculean task of rapidly developing and building a radar which would meet the requirements of troop use. Day and night work, as well as Sundays, was the usual thing (no paid overtime in those

days.) Such was the enthusiasm of this small group that by early January 1938 a further demonstration at Sandy Hook of a more or less embryo model was given for the Chief Signal Officer, and this firming the planning for the initial SCR-268 which was service tested late in 1938 at Fort Monroe.

This development work had advanced the state of the art to the point where the stage was set for a somewhat different radar application, namely, a powerful Early Warning Radar. The initial effort associated with this latter set was carried on to a great extent behind the scenes and after hours, inspired and guided by Mr. Watson. There were no MC's for an Early Warning Radar nor was there the powerful support of the Coast Artillery Corps which was sponsoring the SCR-268. Such sponsorship meant badly needed funds.

During the first half of 1938, a few engineers were added to the small staff of the Radio Position Finding Section. Early in the summer, Lt Col Roger B. Colton, who had been Executive Officer of the Laboratories a few years before, returned to the Laboratories as Director. Col Colton added his inspiration and drive to the entire radio position finding program and ordered full steam ahead on the early warning radar development.

The need for better, more powerful transmitting tubes was great. It is well to remember that the bottleneck in early radar development was the lack of suitable tubes, particularly transmitting tubes. This was true at 110 mc frequency (SCR-268 started on 110 but wound up at 205 mc - higher frequency to permit smaller antennas). It was even more true at 205 mc and higher with

almost nothing in existence above 400 mc's. Tube development had to be pushed. Several parallel programs were initiated to develop a suitable transmitter tube.

The requirement of mobility for fire control equipment forced the operating frequency of SCR-268 to 205 megacycles. The growing requirement for a long range radar to provide early warning information to interceptor squadrons provided impetus for the development of SCR-271 (fixed station) and SCR-270 (mobile) radars. The plans called for a high-powered tube on 110 (approx.) megacycles. This requirement was met by the Westinghouse development of the water-cooled WL-530 tube, a tube, representing by the way, the first major contract of any kind in this new field.

By midsummer of 1938, the early warning radar program was advancing rapidly with Col Colton guiding and aiding by day and night, as only Roger B. could do. A new site for this activity had been found, the Twin Lights Area in Highlands, overlooking the ocean and scene of some of Marconi's early experimental transoceanic broadcasts. By mid August, an experimental model of the SCR-270 was assembled at Twin Lights and readied for a demonstration on an actual bomber flight. This took place on one of those terrible hot August afternoons. Chief Engineer Watson, the designer of the transmitter, expressed great confidence in our new setup stating that we would detect the bomber at at least 65 miles.

Said Roger B., "I'll bet you a case of beer you won't do it."

"It's a bet" replied Watson.

Well, the demonstration started. The usual number of mishaps which one gets with haywire equipment happened. The receiver front-end burned out. A replacement receiver was rapidly put in place while the other one was repaired. But with it all, a continuous track of the outgoing plane was visible on the scope - out to beyond 70 miles. After continuing awhile the pilot was requested by radio to fly in a circle. There, at a range of 78 miles, stood the echo clear and unmistakable. Col Colton had lost his bet. A happier loser has seldom

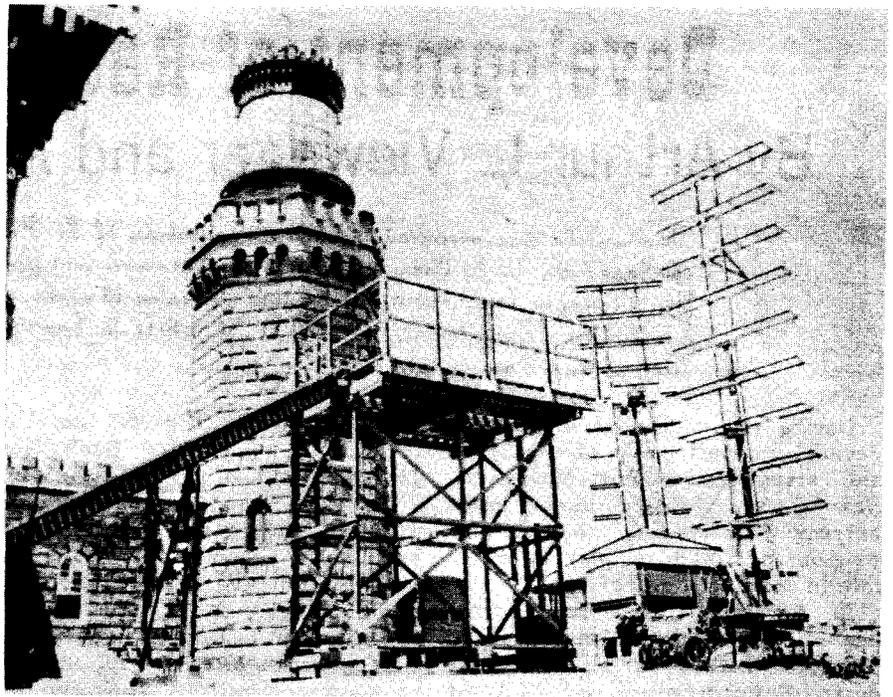


Figure 1 - Early experimental models of SCR-270 and SCR-271 at Twin Lights, N. J.

been seen. The embryo 270 had had demonstrated its great capability and the push was really on to get a set that could be put in the hands of troops.

By October 1938, Westinghouse had delivered samples of the WL-530 tube (water cooled). Concurrently the efforts of Dr. Harold A. Zahl resulted in a high power vacuum switching tube which made it possible to connect the high power (100 kw peak power) transmitter using the WL-530 tube to a common antenna with a sensitive radar receiver. Figure 1 shows some of the early equipment in position at Twin Lights. The turret-like tower in the background was used as a laboratory for work on components.

By June 1939 an engineering model of SCR-270 was being flight tested at the Twin Lights location with fairly consistent tracking of aircraft out to 80 miles and occasional detection as distant as 150 miles. A system setup was then assembled with a pair of SCR-270's, one at Meriden, Conn., the other at Twin Lights and a control center at Twin Lights. This system was demonstrated during November 1939 and used to detect

and track a flight of B-17's from Mitchel Air Base out to the end of Long Island (138 miles) and back. The demonstration was witnessed by Secretary of War Woodring and Generals Marshall, Arnold and Maubornge. It was dramatic and successful.

By the end of 1939 the SCR-270 had truly proven its worth as the first early warning Army radar and it was adopted by the Army in May 1940. A contract for a production quantity was given to Westinghouse in August 1940. Prior to this time the fabrication, as well as the development, had been done at the Signal Corps Laboratories with the assistance of contractors on the manufacture of individual parts and components. On the new contract, Westinghouse would apply its own production engineering to the various parts but were not required to do further development. From laboratory model to first production delivery required only six months, a remarkable achievement for both developer and manufacturer. The contractor delivered 112 sets prior to Pearl Harbor day. Figure 3 shows a Westinghouse manufactured SCR-270B in transport position.

The first Signal Aircraft Warning

Company was formed for service in Panama in January 1940, and a second for service as a part of the Northeast Air Defense Command in February 1940. The fabrication of a fixed station version of the long range radar, SCR-271, was started early in 1940 and two of these sets were shipped to Panama in June 1940. One of these sets, put into operation at Fort Sherman in June, became the first radar in the American defense system. (See Figure 2).

A number of SCR-270's were shipped to Hawaii in the latter half of 1941. There were six mobile stations spotted around the perimeter of Oahu in early December 1941, the one at the northern most

tip being known as the Opana Station. During this period the radars were being operated each day only during the three hours considered most dangerous, namely 0400 to 0700. This short period was ordered in order not to risk burning out the radars for which there were precious few spare parts in the Department of Hawaii.

On 7 December 1941, there were two men only on duty at Opana, the third (normally there) had been given a pass to go to Honolulu. Standard operational procedure called for shutting down the station at 0700. The two men on duty, Privates Lockhard and Elliot, had seen nothing unusual during their three hour tour. The truck, due to

take the two men back to Camp, was a bit late so Elliot, new at the job, suggested he practice a bit with the radar under Lockhard's supervision. At 0702, an echo appeared on their scope such as neither of them had ever seen before, large and luminous, at 132 mile range.

Something must be wrong with the equipment - but it wasn't. By 0720 the two men decided to report to the Information Center at Fort Shefter. Well, the rest is history - how this detection of the Japanese attack went unheeded and the war was on. It is not the purpose of this article to discuss this controversial day.

At this point it may be well to digress for a few words on comparisons between American and British early warning radars since this was a subject of much controversy in the early war months. The capabilities and limitations of radar in general were poorly understood in this early period. The British, under the terrible pressure of actual war had become adept and skillful in the use of their radar system and achieved good results. They used fixed station radars in a system well adapted to island defense. Until Pearl Harbor the U. S. had no comparable pressure or experience in the use of radar equipment, nor had we digested the systems concept in the use of radar. Moreover, the defense of the Continental U. S. posed a much greater problem in terms of quantities of radars required.

Mobile sets were therefore built in order to achieve maximum flexibility of defense, remembering that quite insufficient sets existed for a perimeter defense. However, all too often, comparisons were made which appeared to favor the British CH-CHL Radars. Such radars were therefore imported from England for analysis and comparison in a field set-up at the Signal Corps Radar Laboratory, in Belmar, N. J. The net conclusion was that the SCR-270 as an equipment gave better performance, whereas the British system for presenting and using radar gathered information was better. The value of PPI (Plan Position Indicator) type presentation (used by the British) had been previously recognized and steps were already underway to



Figure 2 - SCR-271 at Fort Sherman, Panama.

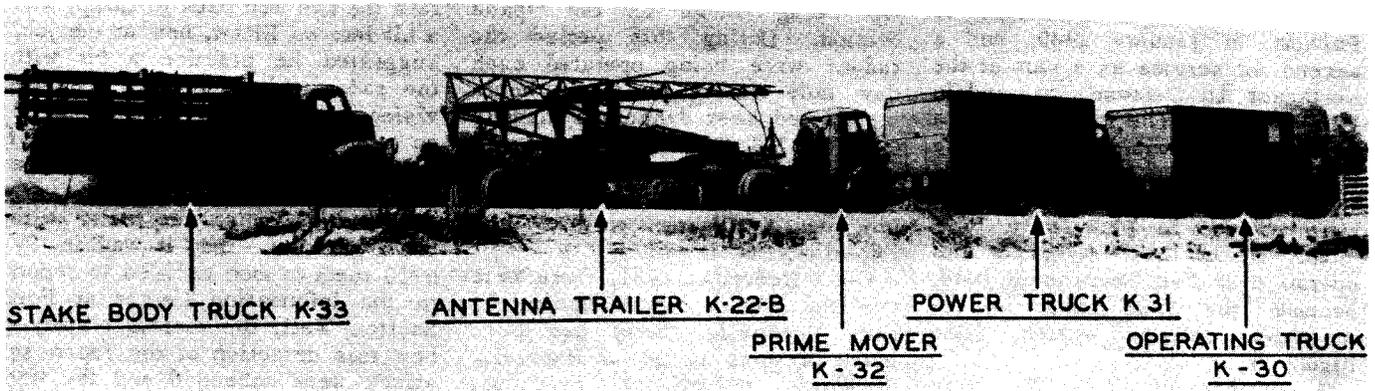


Figure 3 - SCR-270B in Transport Position

incorporate PPI in future 270's and also to supply it as a field modification for existing installations. The advantage of the PPI display over Type A is its ability to display a large number of echoes simultaneously, whereas Type A is limited to one target at a time.

During late 1941 and 1942, a network of approximately 25 SCR-270's was installed along the Pacific Coast, with a few in Mexico and Canada, to feed early warning data on aircraft into the various information centers. A similar network had previously been installed along the Atlantic Coast, with stations being added during 1941 in Newfoundland and Iceland. It can, therefore, be seen that by the end of 1941, America had an existing early warning Radar System around its perimeter, and that the SCR-270-271 series of Radars were the heart of the system.

A number of SCR-270 sets were procured for the Marines, and these sets were used during amphibious operations on Guadalcanal and other Pacific Islands. Marine officers were full of praise for the sets and stated that each SCR-270 was the equivalent of a squadron of planes in the performance of an early warning function. Since planes were scarce at this time, the radar sets were priceless.

In the Fall of 1940, British Scientists had introduced their improved magnetron to our defense officials and the decision was made to create Radiation Laboratory (physically at MIT) for the purpose of developing and exploiting microwave radar. It was further decided

that the Signal Corps Laboratories should proceed with all haste into production with our lower frequency radars to gird for the coming war.

Radiation Laboratory proceeded with the development of a Microwave Early Warning Radar - initially called MEW and subsequently AN/CPS-1. This set operated at approximately 3000 megacycles. This radar, because of its high frequency, could achieve a much narrower antenna beam for a given size antenna. It can, therefore, resolve or distinguish between multiple targets far better than a long wave radar such as the SCR-270. So the successor to the SCR-270-271 series was in the making - an evolutionary process. However, MEW sets were not put into operation until 1944, mostly in Europe. By this time the threat to the Continental U. S. had subsided considerably.

A few more words on the final course of the SCR-270-271 may be of general interest. To increase the long range capability of the radar, a series of modifications were developed during 1943 and 1944 at the Signal Corps Laboratories resulting in a final version of SCR-271 with the following characteristics: Transmitter Peak Power - 500 KW (using the same WL-530 tubes); Pulse Width - 20 microseconds - Antenna - 64 dipoles 8 x 8 configuration; Antenna Beam Width Approx. 10°.

This final version mounted on a 400 ft. tower at Oakhurst, N. J. succeeded in tracking a single P-51 aircraft out to 270 miles, losing the target only because of the line-of-sight limitations. The U. S. Air

Force, as a separate service, took over cognizance of early warning radar in February 1945. This included the SCR-270/271. Many of these sets were later used for long range meteor detection and various propagation efforts.

The 270 played a part in still another long range effort - another "first"! This program was initiated at Evans Signal Laboratory in 1945 and is known as "Diana" using the major components of SCR-271, suitably modified and incorporating the frequency modulation techniques developed by Maj Armstrong, the equipment succeeded in sending pulses and receiving back radar echoes from the moon in January 1946. This also is history, and will not be further discussed here.

The Principal Technical Characteristics of the 270-271 series have been summarized and are included as Figure 4.

(See following page).

## CHANGE IN SYMBOLS

Mailing and address symbols of the Directorate of Communications-Electronics, Hq Air Defense Command, have been changed from the former ADOCE designation. The Directorate now is addressed by ADOAC.

In accordance with the change, the C&E Digest should be addressed as ADOAC-DD, and the C&E Technical Library as ADOAC-DL. Correspondents are requested to change their records accordingly.



FIGURE (4)

## TECHNICAL CHARACTERISTICS

	SCR-270, 270B SCR-271-A	SCR-270-BA SCR-271-D	SCR-270-DA SCR-271-DA	FINAL VERSION (EXPERIMENTAL)
Frequency (megacycles)	104-112	104-112	104-112	104-112
Peak Power (Kilowatts)	100	100	100	500
Pulse Length (microsec)	10 to 30	10 to 30	10 to 30	10 to 30
Approximate Average Power (Watts)	2500	2500	2500	2500
Noise Figure (db)	12db	12db	6db	6db
Antenna (Broadside Dipole Array)	4 wide by 9 high (non-resonant)	4 wide by 8 high (resonant)	8 wide by 4 high (resonant)	8 wide by 8 high (resonant)
Azimuth Beamwidth (degrees)	28	28	11	11
Indicator	5 inch A-scope	5 inch A-scope	12" A-scope 12" PPI-scope	12" A-scope 12" PPI-scope

## PHYSICAL CHARACTERISTICS

SCR-270      *Antenna trailer, prime mover, operating truck, and antenna storage truck.*

SCR-271      *Original set used building-tower combination 36 feet high with antenna on tower.*

SCR-271-D    *100 foot tower with antenna plus separate building.*

*A total of approximately 800 sets was built.*

D.C. RIPPLE VOLTAGE OF  
FPS-20 R.F. MONITOR

The present method of checking the D.C. ripple voltage of the radio frequency monitor of the FPS-20 radar set, reports MSgt Irwin J. Lyon, Moody Air Force Base, Valdosta, Georgia, is to remove the assembly from the R.F. monitor cabinet and remove the bottom plate (protective covering), thus gaining access to checkout points. Power is applied to the R.F. monitor and two men are required to adjust the ripple voltage in accordance with paragraph 6-30, page 6-15, through paragraph 6-36, page 6-17, Section VI, T.O. 31P6-2FPS 20-2. This method creates a safety hazard to personnel performing the checkout as they are exposed to high voltage.

To disassemble and assemble the R.F. monitor takes quite a bit of time also.

The ATC personnel at Moody AFB installed a female connector, part number 225, with red insulator on

the back of the R.F. monitor halfway between the ripple adjustment point and the element tolerance compensator point, with a shielded type lead size 20 connecting the connector to pin 6 of tube V5. The shield of the lead is grounded to the chassis neat pin 6. To check out the set after modification insert a test probe into the female connector, and with the use of the scope adjust the ripple voltage as necessary.

NAVIGATOR TRAINING  
FOR EW OFFICERS

Single-rated electronic warfare officers (AFSC 1575) will not be excluded permanently from upgrade navigator training, the Air Force has announced. Shortage of manning in this specialty currently precludes withdrawal of these officers from duty.

Once Air Force-wide requirements have been satisfied, a new directive is planned that will permit electronic warfare officers to sub-

mit applications for upgrade training.

AFSC 1575 is not now, nor is it projected to be, obsolete, according to the announcement. Therefore there is no threat of losing flying status solely because an officer possesses this single-rated specialty.

## NON-HOWLING SPEAKER

The distracting howl of indoor public address systems caused by acoustic feedback of room reverberations can now be avoided without paying a high price in gain.

Bell Telephone Laboratories claims that a new electronic method it has developed minimizes howling, or "singing". In fact, it says it permits a two-fold increase in the loudness of a conventional PA system without incurring instability.

Key to the development is a constant-frequency shift device, called a frequency shift modulator. It is inserted into the circuit between the microphone and the loudspeaker.