The Japanese Radar Effort in the SWPA in WW2.

(Prepared by R. W. Madsen August 10,2018.)

Introduction.

In JPVM's Electrical Engineering-RRB (Radio Research Board) research library at Sydney University were copies of many English translation radio & communication journals published in Japan between 1936-1940 by a number of Telegraph & Engineering Institutes with very substantial memberships which gave a clear indication of the extensive capabilities of research scientists & engineers in Japan & the considerable underlying manufacturing capabilities available to them which had been built over 40 odd years.(in 1937 Japan had 2,000,000 domestic radios, automatic telephone exchanges since 1924 after the earthquake, television & an overseas short wave broadcasting transmitter).

Most of the information published on Japanese radar after WW2 comes from a Short Survey of Japanese Radar compiled in October-November 1945 by US Operations Analysis & Technical Intelligence personnel who were able to interview Japanese engineers & scientists involved with their radar & also obtain examples of equipment for shipment back to the US- there are other sources based on information obtained during the war itself.

Whilst early work in Japan on split anode magnetrons did lead to their development of a 10 cm. cavity magnetron in 1941 at 500 watts, only one set for the Navy was produced in quantity (set No.22 -) & later attempts at shorter wavelengths were never progressed to the production stage. The lack of a high powered magnetron was the most significant difference between US-Aust. microwave radars & the Japanese equipment although in the 200 mc/s range there were similarities.

The experience of the Japanese in copying captured English & American radars & producing sets from plans & samples provided by Germany cannot be considered a success & the initial basic physical principle used of a continuous Doppler detection line for AW was supplanted by the adoption of pulsed radars, an idea past onto the Japanese by the Germans in 1940 based on their knowledge of English radar.

The Japanese seem to have had the unfortunate experience of producing many prototypes but not many went onto production & were installed for use with the Navy or Army, but noticeably they lacked gun laying radar & had little defence against the B-29's, albeit that their AW radar & observer network were sufficient to pick up incoming raids. Their radars were easily susceptible to jamming & they had no inbuilt safeguards to deal with this.

By the end of 1942 the Japanese had lost the Guadalcanal campaign & they recognised that radar had been a decisive factor in this loss & the IJN set about installing more warning radars on their ships.

A published Japanese report (held in the Elec Eng Library) in July 1938 (Multiple Courses of an Aeronautical radio Range Beacon-) highlighted the effects of mountainous terrain at Kyushu /Kagoshima which made the use of the radio beacon very dangerous & would have been a warning to radar planners of Operation Olympic for November 1945.

The English Chain Home radar warning equipment was designed on the basis that the transmitter & receiver apparatus was already commercially available (Metrovick & Cossors) which was to provide an economy in cost & development time. Similarly the receiver for the English airborne ASV was based on the 200 mc/s television frequency. In Australia for the design of radars, the economy of weight & power requirement was of the greatest importance considering the vast area of the continent & the ocean shelf where surveillance was required. In Japan, the Doppler continuous line warning system was designed first with economy in mind by Dr.H. Yagi (& Prof. K.Okabe) but it proved to be a false economy as it did not meet the essential requirement of finding position- other false economies were to emerge in Japanese radar work not the least being the lack of co-operation between the Army & the Navy in the design & production of sets with the same purpose. The economy in the US of mass production was well understood & in Germany the efficiency there appears to have been in the well made modular designs of radar sets as a means of overcoming a lack of skilled radio/radar technicians when repairs were required.

The early installation of a Japanese AW radar in Rabaul in March 1942 (similar one was captured at Henderson Field/Guadalcanal in 1942) almost certainly gave them early warning of bomber raids by US & RAAF bombers (B-17's, Hudsons) coming from Aust./Townsville. The RAAF LW/AW stations, even when operating in enemy held territory, seem to have had something of a charmed existence in not being eliminated by the enemy.

English versions of Japanese Radio Journals 1936-1939 in JPVM's Research Library –Sydney University.

It appears that the J.I.T.T.E of Japan (Institute of Telegraph & Telephone Engineers) & the I.E.C.E. of Japan (Institute of Electrical Communication Engineers) published English versions of their papers typically condensed to 2/3 the original length & sent complimentary copies to Sydney University arriving 12-18 months after the original presentation date. The following papers are listed to give some indication of the radio communication research work that was published.

Original Date.	Paper.	Author.	Institution.
1935	Radio telephony on 68cm. with parabolic reflectors	K. Morita	Tokyo Uni.
1937	A new TV Transmitting cathode ray tube-Tecoscope	M.Nagasima	Tokyo Electric
1936	Wireless Picture Transmission between Tokyo –Berlin	T. Amisima	Ministry-Coms
1936	Inaugural Address by President of J.I.T.T.E.	R.Nakayama	J.I.T.T.E.
1937	50 Kw Short wave Broadcasting Transmitter	T. Nakagami	NEC & I.T.Co.
1936	Mechanism of split-anode magnetron oscillations.	K.Okabe	Osaka Uni.
1938	Air-cooled magnetron for generation of 20-40 cm waves	M. Kobayasi	NEC
1938	Multiple courses of an aeronautical radio range beacon.	S. Yonezawa	Ministry-Coms
1939	Studies on ultra short waves for multiplex telephony	S. Yonezawa	Ministry-Coms
1939	Experiments on the steerable antenna	H. Takeuchi	I.T. Co.

Some brief comments on each of these papers are:

Radio telephony: A tube of Type US 80 B (similar to a Bell triode) was used to generate electron oscillations of 68 cms in wavelength at an output of 3-4 watts. A large parabolic reflector (2.5 metres across) was employed with the antenna located at the focus. The longest distance over which tests were carried out was 78 km. Reference was made to a Bell Systems Technical Journal of January 1935. [Note. It was Kiyoshi Morita who made suggestions to Shigeru Nakajima at JRC- Japan Radio Company on ultra short wave tubes & later made drawings of a magnetron to have JRC build it which attracted the interest of both Shigeru Nakajima & his older brother Yoji Ito at the Naval Research Institute where he was working on transmissions up to the ionosphere-this finally would have been around 1937].

Tecoscope: A comparison of the Tecoscope with the Iconoscope the commonly used CRT was that in spectrum-sensitivity characteristics the Iconoscope was insensitive to red, while the Tecoscope was quite sensitive to red. & even to infra red.

Berlin-Tokyo Wireless Picture: Tests on wireless picture transmission were carried out in 1934 over 3,000 km & satisfactory results obtained. During the Berlin Summer Olympics of August 1936 reception in Japan was between 10.00 pm & 4.00 am with the maximum strength of wave between 2.00 – 3.00 am when the average reception field intensity was from 10-20 db. Reception during the Olympics was entirely with time modulation method & it was not difficult to eliminate fading & even with field intensity of 4-6 db satisfactory results were obtained.(8,900 km). After the Olympics experiments with amplitude modulation were carried out & under favourable atmospheric conditions satisfactory results were obtained even with the AM system. After Berlin, experiments were carried out with London & San Francisco.

Ryuji Nakayama President's Address: He was well informed about developments in Western countries & was fluent in both English & German- was an unmoving champion of extending Japanese influence in China by building a great wireless station in China in direct opposition to a similar proposal by the British Marconi Wireless to link China in its chain of worldwide wireless stations. His very long Address deals with the first 70 years of telegraphy in Japan & the more recent past 20 years where phenomenal growth had occurred including manual to automatic exchanges, teleprinters & carrier system telegraphy used through telephone lines, the appearance of vacuum tubes for TV-Radio beacons-wireless photo transmission-radio compass, “”Shortwaves the Almighty” broadcast station for overseas broadcasts, major reduction in cost of vacuum tubes & broadcast receiving sets. In the field of communication Japan was then ranked as 5th after the US, England, Germany & Russia in the world. In the field of radio communication Japan had or was planning 50 direct channels to Manila, London, America, Berlin, Columbia, Chile, Belgium, Sweden, Paris, Siam, French Indo China, Italy & Canada. Indirect channels were to be had through London. Future plans also included over 3 years telephone cables between Japan & Manchukuo, wireless telephones on trans-oceanic liners & a 50 kw shortwave transmitter for foreign broadcasting.

Looking back it was seen that Japan was a victim of her own sense of power & superiority. Success in China up to December 1941 convinced them of their equipment superiority & that there was no need to enter into costly electronic developments & so manufacturing plants continued with their normal civilian production.

50 kw Short wave broadcast transmitter: The Japanese Overseas Broadcast operations were started in June 1935 at 20 kw shortwave with directive antenna situated at Nazaki & broadcast to San Francisco for 1.00 hour at 2.30 JST. & the response was very good. In 1936 tests to Europe were started at Nazaki & the East Coast of North America & these also were considered successful (to Europe at 4.00-5.00 am

JST) & as a result a 50kw transmitter was planned. Further regions were looked at & for the Straits Settlements & Java in January 1937 2 20kw transmitters & 2 frequencies were considered suitable.

The time for each broadcast had to be selected for the convenience of listeners (usually 8.00-11.00 pm local time & the frequency chosen had to be suitable for that time (noting that the strength of the broadcast will not overcome a bad frequency) also depends on the season, direction, distance & time. The transmitting power has to be the strongest available & the antenna directive but not too sharp so that a wide surface area may be had.

There were 4 shortwave broadcast areas: I) Europe-London 8.00-9.00 pm local time II)Eastern North America-New York 4.30-5.30 pm local III) Western North America-San Francisco – 9.30-10.30 pm local IV) Straits Settlement, Java, Australia-Sydney 11.00-12.00 pm local on a frequency of 15,160 kc broadcasting news in Japanese, English & Chinese, Music & talks..[BBC Daventry in 1933 was broadcasting at 10-20 kw to Australia in their Zone 1 as call sign GSD 11,750 Kc 25.53 mtr & GSF 15,440 Kc 19.82 mtrs at 6.30-8.30 pm Sydney time]{In 1939 the "Australia Calling" programme call sign VK3LR broadcast from Lyndhurst, near Melbourne on 9,580 Kc , 31 metres & in June 1941 as VLG was inaugurated as Radio Australia at 10Kw}.

To facilitate transmissions in the desired directions 5 new steel towers were built (1 X 85 mtrs & 4 X 100 mtrs). For Straits Settlements, the antennas for the western coast of North America were employed as it is situated so that the reverse side of these antennas may be used.

Split anode magnetron oscillations: Okabe deals with both 2 split & 4 split magnetrons but says there is no fundamental point of difference. Included in his references are 3 well known researchers in the west- K.Posthumus- Nature 1934 (The work of Posthumus in 1935 led to a much clearer theoretical understanding of the operation of the magnetron), G R Kilgore- I.R.E 1936 & E.C.S Megaw Nature 1933/1936. [Prof Okabe at Osaka University in 1936 was working under Dr. H.Yagi & he was given the assignment to develop Yagi's idea of a Doppler beam system where a beam if interrupted by a passing aeroplane would produce a strong beat rather than the normal uniform signal. This had followed interest from the Japanese military & although the system only required a small amount of power it could not give a definite position of the target along the line. In 1939 a station was set up at Hankow at 3 watts & in 1940 a variety from 3-400 watts were built until 1941 when the first Doppler system for aircraft warning was set up. The longest system was between Shanghai & Formosa-400 miles]{Capt. Yoji. Ito who was the head of magnetron research centred on the Japanese Navy was a former student of Prof. Okabe}{Ito's younger brother was Shigeru Nakajima working at JRC & in 1938 they worked jointly on an 8 segment magnetron Tachibana "Mandarin" giving 30w at 6cm & by April 1939 the design had evolved into "M3" with 8 cavities in a copper block giving 500 w at 10cm although this seems a very high output considering at the end of the war manufactured magnetrons were only producing 400w }.

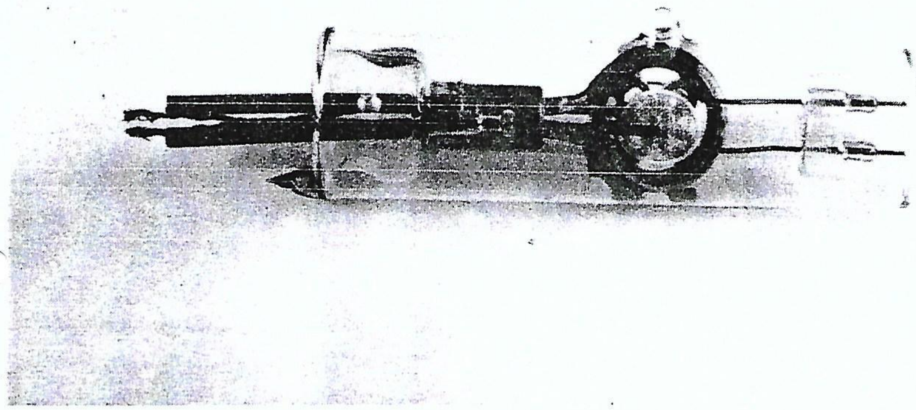

Fig. 18.4 *Water-cooled magnetron M3, (λ = 10 cm, continuous power output 500 W)*

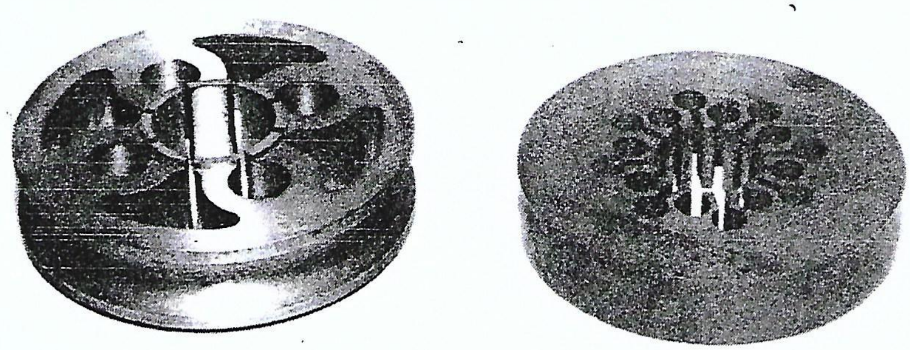

Fig. 18.5 *On the left is shown a 10 cm M3 type anode, and on the right an anode of 3 cm wavelength is shown*

Air Cooled magnetron for 20 & 40 cm waves: Better results expected from a 6 split anode magnetron compared to a 2 or 4 split anode. Masatsugu Kobayashi was at NEC in 1938 when research engineers noticed during testing of a high frequency transmitter that rapid fading of the signal occurred whenever an aircraft flew over the line between the transmitter & receiving meter. Kobayashi recognised this as the beat-frequency interference of the direct signal & the Doppler-shifted signal reflected from the aircraft. He suggested to the Army that this phenomenon could be used as an aircraft warning method. In early 1941 a Doppler Interference Detector was put in operation between 4.0-7.5 Mhz involving a number of widely spaced stations & could detect planes at up to distances of 500 km in the China region.

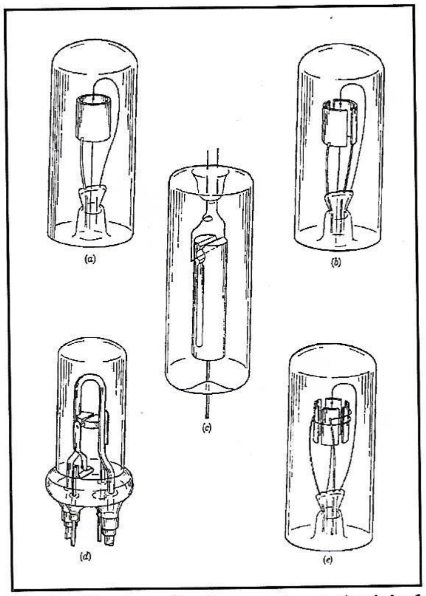

Fig. 1 Structure of early magnetrons; a) original Hull diode; b) split anode; c) split anode with internal resonator; d) improved split anode; e) four segment anode.

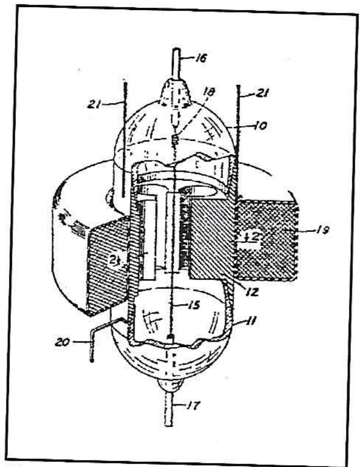

Fig. 2 Four-cavity magnetron developed by A.L. Samuel at the Bell Telephone Laboratories in 1934. The anode (12) was inserted into a thin-walled copper tube, a thoriated tungsten filament (15) was supported axially by tungsten rods (16, 17) sealed into glass domes (10, 11) which were then sealed to the ends of the copper tube. The magnetic field was provided by a solenoid (19).

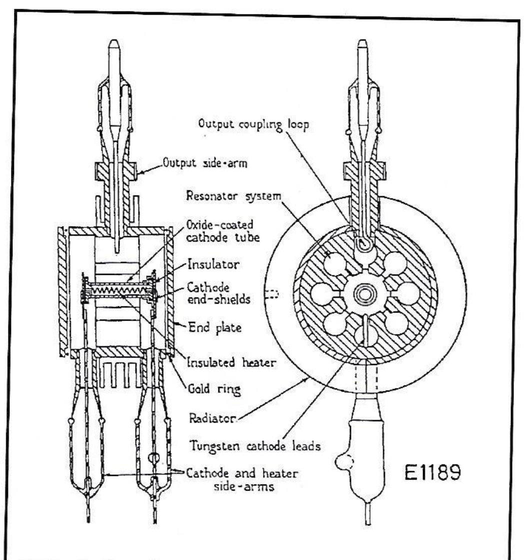

Fig. 6 Diagram of the magnetron brought to North America by the Tizard Mission in 1940. Type E1189.

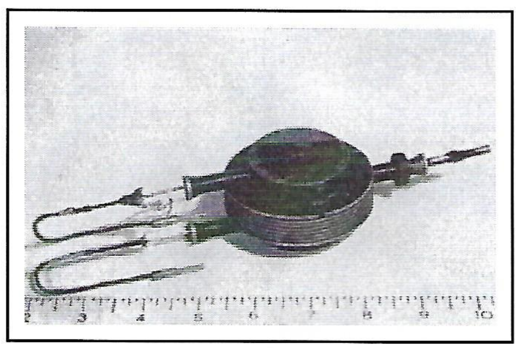

Fig. 7 The multicavity, microwave magnetron brought to North America by the Tizard Mission in 1940 (E1189 Serial No. 12); the seed from which microwave radar grew.

Aeronautical Radio Range Beacon producing multiple courses: A Radio Range Beacon station was installed at Kagosima in Kyushu in 1936 & was the 1st of its kind for safer flying on the Taiwan-Japan route. The station operated at 1kw output at a frequency of 260 kc & was an aural system. Four insulated steel poles 60 metres high were placed at the corners of a square having a diagonal distance of 200 metres. & the system excited by 6,600 volts from underground cables. Fields in the form of unbalanced figures of 8 are radiated out & the beacon course is determined by the intersecting fields of equal intensity. In October 1937 on a scheduled airliner it was found that the course towards the Kosiki Islands was split, forming so-called multiple courses at positions along the route above these islands & also at another location being far off the true course- further tests were made in 1938. As a result of these tests it was presumed that the multiple course phenomenon was due to the reflection & diffraction of waves from the mountains. There was the apprehension of finding that the multiple course phenomenon was unavoidable in a land like Japan where mountains are almost adjacent to the sea & the topography is exceptionally rough.

Ultra Short wave for multiplex telegraphy: Consideration given to special properties of an ultra-short wave transmitter for multiplex telephony at frequencies between 72 & 78 megacycles per second & carrier output power of 35-60 watts. Experiments were carried out to reduce distortion.

Experiments on the steerable antenna: Describes the results of the characteristics found for an antenna designed so that the radiation directivity in the vertical plane can be easily changed.

The Short Survey of Japanese Radar in November 1945 & Technical Reports.

From the information in these reports it can be readily considered as Japanese Navy equipment, including their magnetron work on the one hand, & Army sets, principally used for the defence of the Japanese homeland, on the other, recognising however that the competition between these two arms of the military in radar & other matters was the cause of a great deal of inefficiency , duplication & non standardisation of components until steps were taken in August 1943 by a joint Army-Navy Committee to correlate progress & at least 90 components standardised. A total of 30 different types of radar were built by the Japanese during WW2 with at least 7,200 sets of all types being built-

IJN radar in SWPA.

In the SWPA it was the Japanese Navy which had radar at sea, on land & in the air which is what US & Australian forces had to contend with. It is thought that probably the first examples of IJN shipborne radar were experimental sets on light cruisers Oi & Kitigami which apparently were the only Japanese ships to begin the war with radar installed. These Type 13 experimental sets were for air warning at displayed ranges of 0-150 km & 150-300km & operated at 150 mc/s (2.0 metres) using a duplexed aerial whereby a gas discharge “valve” was placed across the receiver transmission line to protect that unit from the heavy transmitter pulse. The production set was considered to be highly satisfactory to operate & eventually 1500 were produced. The Kitigami in 1941 operated with “Long Lance” torpedo tubes but in October & November of 1942 was involved with the transport of troops to the Solomons & Rabaul & then in January 1943 was assigned to reinforce Japanese forces in New Guinea at Wewak-she survived the war but had suffered damage. The sister ship Oi was also converted from a torpedo cruiser to a fast transport but was sunk by a submarine in 1944.

The first Japanese radar equipment captured by the US was a heavy Type 11 (Mark I, Model I) at Guadalcanal in August 1942 which operated on 100 mc/s set up at the newly constructed airfield (Henderson Airfield) for Air Warning. The first set had already been set up at Rabaul & some 80 sets of this type were produced but had the disadvantage of weight & not suitable for the lightweight role.

The first ASV type airborne search radar for the IJN operating out of Rabaul with "Betty" bombers do not appear to have been brought into use until late 1942. This set, the **H-6**, had a wavelength of 200cm, 3kw power & range of 110 km (150Mhz & 146-167 Mhz at the receiver-it could use any one of 3 antennas at will giving it both search & homing abilities-a Yagi type aerial protruded from the nose& a smaller antenna on each side of the rear fuselage of the plane. It gave very satisfactory search service as long as high definition was unnecessary-2,000 built- It is believed that technicians at Rabaul converted 11 of these sets into the equivalent of SCR 602.

Research started on the H-6 in December 1941 & manufacture was by Nihon Musen, one of the 3 large radar producers (Sumitomo Communications & Tokyo Shibaura Denki, the other 2). 2,000 H-6 were produced & 1,000 Taki-1's for similar function supplied to the Army.

The IJN Radar No 12 was the 1st portable (mounted on a 4 wheel trailer) air warning set (Mark 1, Model 2) which operated at 200 mc/s giving a range of 100 km from a power of 5 kw- it was designed to replace the bulky No 11 but had a similar circuit design . Raising the frequency to 200 mc/s greatly reduced the antenna size to about 14' X 7'. The transmitting antenna was placed in the upper bay & an identical receiving antenna in the lower bay. In this manner a quite narrow beam was projected, less than ½ that of the No 11 set. The power output, however, was only 5 kw. Operations people reported that this set was one of the least satisfactory of their warning radars with frequent breakdowns & unstable transmitter frequency. Nevertheless many were apparently seen in the Solomons, New Guinea & Netherland East Indies & a few even on the Japanese homelands as standby equipment. There were later sets with quite different antennas & at a lower frequency (150 mc/s).

Up to the end of 1942, when Guadalcanal was lost, the Navy had relied upon optical weapons & then realised that radar had been a decisive factor in this loss & started to install radars as quickly as possible. It should be mentioned that by the end of 1942 at least 23 ships & aircraft carriers already had either Type 13 or Type 22 radars plus "Ise " which had a Type 21. By the end of 1943 at least a further 43 ships plus aircraft carriers had radar installed again of the Types 13, 21 & 22. Type 13 was an anti-air set operating at 200 cm with 10 kw of power, Type 21 was an anti-air, surface detection set operating at 150 cm & 5 kw of power, the Type 22 was an air warning set but provided moderately accurate data for gunnery control also-it operated with a 10 cm magnetron water cooled M-312) & a power of 6 kw for a range of 25 km. These radars were installed on major ships (battleships & cruisers) as well as destroyers & light ships. The aircraft carrier Shokaku had a Type 21 installed in September 1942 & the Shinano finished as a new ship near the end of the war had a Type 13 & Type 22. (the Taiho had a Type 13 & Type 21). The Japanese aircraft carriers at Coral Sea & Midway did not have radar whereas the US aircraft carriers did have Air Warning.

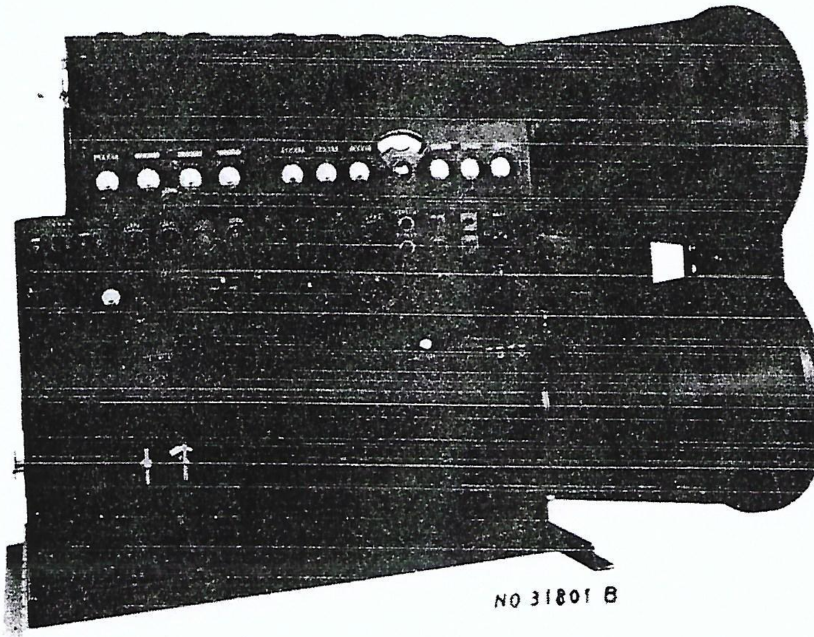

Fig. 18.11 *10 cm surface detection and targeting radar No. 22*

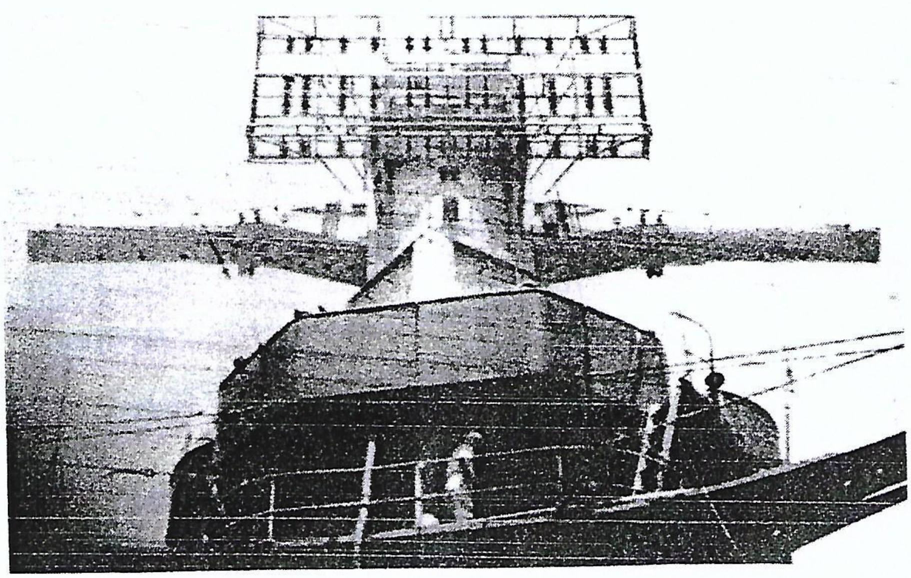

Fig. 18.12 *The antenna of the 1.5 m early warning radar No. 21 onboard 'Ise'*

In 1944 & 1945 many Type 13's, 21's & 22's were installed (approx.. 162, 19, 188 respectively) mostly by experienced radar engineers who had to be taken away from their work in factories which disruption was further increased by production workers being taken into the Army & Navy & being replaced by very young people of school age even, plus the effect of B-29 bombing raids starting in November 1944 & later especially from Iwo Jima & also the raid of March 9-10, 1945 which was devastating to Tokyo.

It appears that the Navy did development work to the prototype stage at least on a GCI set ("Friendly Aircraft Locator" Hama 62) which was land based & operated at 200 mc/s with a range of 130 km. The display was with a range scope & an azimuth pip matching scope-the IFF component was to be an M-13 airborne set compatible with the GCI transmitting on 150 +- 5mc/s & so that the response can be given by any one of 5 different codes for added identification precaution. The operator in the plane can hear his own set if it is responding. It took 9 months of development & production readiness & was only coming into use by the navy at the end of the war.(The Army quite separately had produced IFF sets to prototype /"pathfinder" numbers 50-120, Transmitting on 184 mc/s & receiving at 175 mc/s. Tachi 17 & Taki 15 designations).

Type 13- Small Size Air Warning: This set was suitable for land operation as well as on a ship or small vessel. It operated on 150 mc/s at 10 kw & a range of 100 km. A single antenna was used for "transmit" & " receive" with a gas discharge "valve" to protect the receiver. The antenna appears to have been a 2 X 4 element array backed by an identical reflector array. This set is noted for its small components.

Type 21- Shipborne Air Warning: Originally built for land use but with a different antenna. The set operated on 200 mc/s at 5kw & a range of 100 km against a battleship. The mattress antenna is small & rugged designed to be installed on the top of the ships foremast (it used the same equipment as Type 12). Completed in June 1942, had a wavelength of 1.5 metres & used 2 X T-310 transmitter tubes. The set was manufactured by Tokyo Shibura Denki.

Type 22- Shipborne Air Warning (10 cm).: This set appears to be one of the most satisfactory equipments used by the Japanese Navy. It was a 10 cm set at 2 kw & a range of 25 km against a battleship. Large numbers were installed (500). Research began on this 10 cm set in October 1941 & the equipment went through numerous modifications & improvements during the following 3 or 4 years. A pair of small horns, one for transmitting & one for receiving & mounted to rotate on a base in such a way as to always point in the same direction at once, provide a simple & rugged antenna structure without need for the loss inherent in the T-R tube arrangement. The set is very heavy being comprised of more than a dozen components (transmitter, receiver, indicator & radiator). The transmitter is powered by an M-312 magnetron, the anode being water cooled by a motor driven pump. Peak power is approximately 2 kw with 11,000 volts applied to the magnetron. A blocking oscillator provides the 10 microsecond keying pulse at a rate of 2,500 per second controlled by a tuning fork. The receiver is a superheterodyne with crystal detector and magnetron M-60 local oscillator. The display was on 2 cathode ray tubes the first an "Indicator for warning" showing all targets up to 60km with 5 km pips & the second, a "Range Operator" which gives an expanded view of about 1,000 metres of the range as selected. The true range is read on a dial when the target pips leading edge is set just even with a vertical line inscribed up the face of the scope.

The antenna were a pair of small horns, one to transmit & the other to receive & mounted to rotate on a base in such a way as to always point in the same direction at once & which were simple & rugged. Horn antenna design was known in the US by 1938 from the work of W.Barrow & G C Southworth & had the advantage of operating over a wide range of frequencies –the ends of the waveguide were flared out to make a horn & tapered to allow most of the wave energy to radiate out into space with minimal reflection back down the waveguide & with a wide aperture of a horn to project waves in a narrow beam. The antenna equipment within the set included an antenna turning motor, antenna control handles and antenna azimuth indicator.

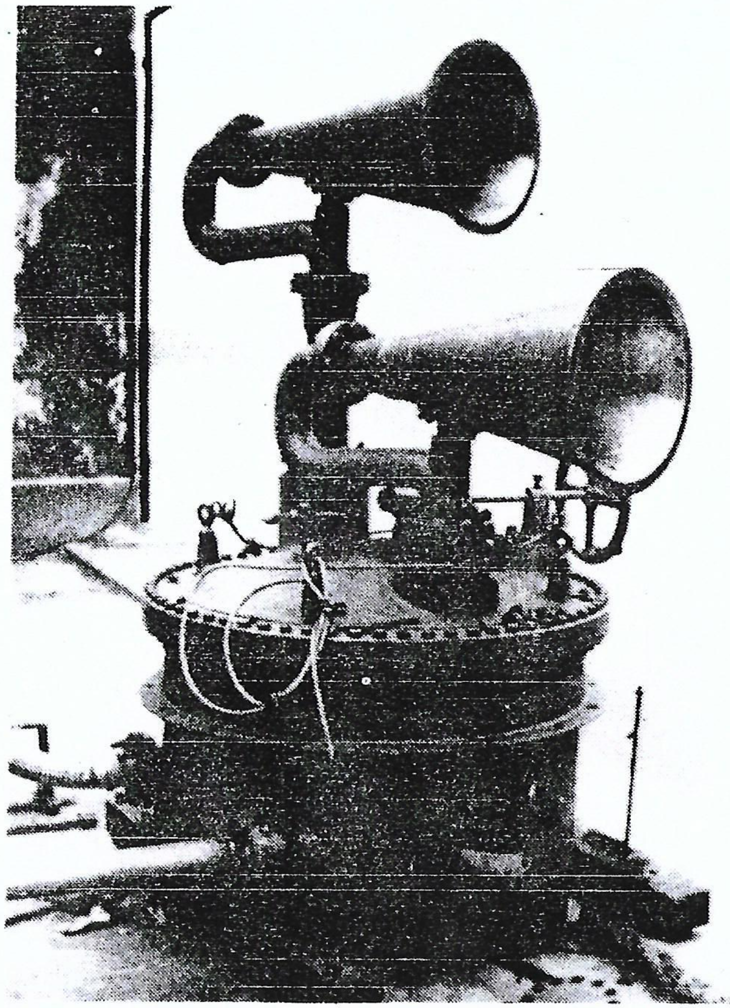

Fig. 18.13 *Water-proof, pressure-proof antenna of 10 cm radar for a submarine*

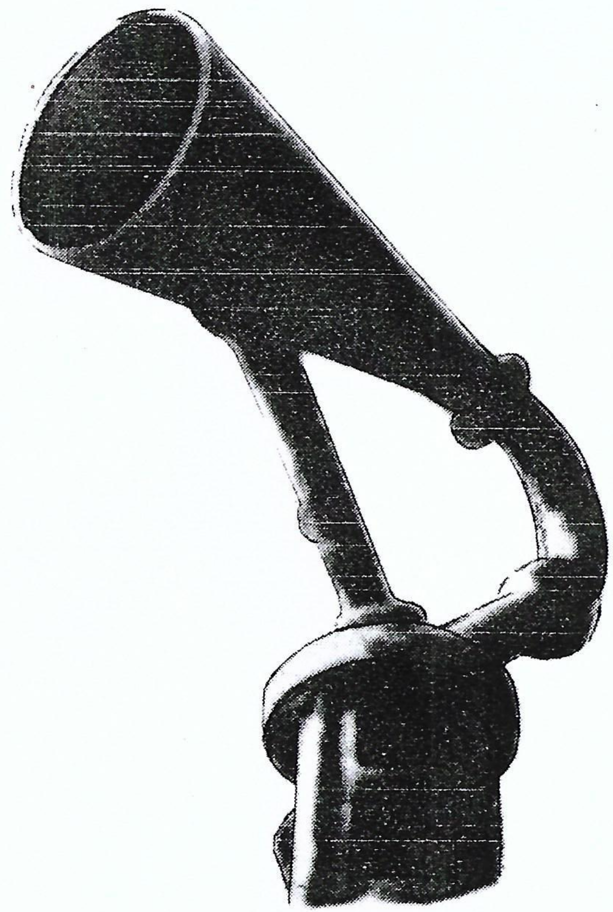

Fig. 18.14 *Transmitter, receiver and indicator of 10 cm radar No. 22 installed inside a submarine*

Valve production for metre & microwave sets: Valve research & production appears to have been carried out by the 3 manufacturers of radar equipment (Nihon Musen, Tokyo Shibaru Denki & Sumitomo Communications) in their Vacuum Tube Departments.

The Vacuum Tube Dept. of Nihon Musen at the Mitaka plant (8,000 employees working a single shift) was well led by Shigaru Nakajima (see below) & had a staff of 60 scientists & engineers. A vacuum tube expert from NM went to Telefunken in Germany for 2 years in 1937 but in exchange Telefunken only sent a commercial representative to Tokyo as by this time after 15 years of commercial relationship Telefunken thought that Japan had little technical knowledge to give in exchange. Nakajima was given a lot of credit for the design of magnetrons for the Navy & Army radars.

At Tokyo Shibaru Denki (the pre-war counterpart of General Electric at Schenectady) vacuum tubes of all types were made at the Yobe plant & vacuum tubes for large transmitters made at the Yamagi Cho factory –Kawasaki.

Considerable research appears to have been done by Sumitomo Communications between 1940 & 1945 (as per the Short Survey) on many aspects of radar equipment & valves including: Thoriated tungsten wire (1941-1945, Takasaki plant),Temperature proof & moisture proof parts & materials (1944-1945), Gas Discharge valves (1940-1944), Ultra High frequency Transmitting tubes for generating impulse waves (1942 TR-594 4mtr wavelength, 50 kw, 1943 TA-1504 1.5 metre ,5 kw, TA -1506 80 cm , 1 kw), Cathode ray tubes (1942-1945), Vacuum tubes for Wurzburg Radio Locators(March 1940-1945)[Imitation Telefunken vacuum tubes LS-180, LG-1], 1.5 mtr Portable Radio Locator.

It is evident that if Sumitomo were the only people working on tropic proofing, and from as late as 1944, their understanding for this requirement in the New Guinea area of operations, which is when they would badly have needed it to keep their radars running, was severely lacking.

IJN radar countermeasures: Both the Navy & the Army appreciated the need for knowing what manner of radar sets were being used against them. Both had developed a line of search receivers with various means of displaying or recording the signals picked up. Some were equipped with scope presentations whereby homing on a signal was possible. It is not known in the New Guinea area of 1942-43 how such search receivers formed part of the operations of the Japanese army units.

The Japanese 10 cm magnetron & the 2 brothers-Yoji Ito & Shigeru Nakajima.(1939-1945.)

Captain Yoji Ito (1901-1955) & his younger brother Shigeru Nakajima (1910-) were the sons of a primary school master & both trained at university in electrical engineering , learnt German & because of their separate interests in investigation of the ionosphere & electromagnetic therapy, both became involved with a magnetron at 10 cm wavelength.

Yoji Ito was commissioned into the Navy & spent time at sea before going to Dresden to study under Heinrich Barkhausen & obtained a Doctors degree in 1929. On his return he was assigned as a researcher to the Naval Technology Research Institute (NTRI) which had been formed in 1922 with 1st rate scientists, engineers & technicians. His microwave investigations of the ionosphere & the Kennelly-Heaviside layer started with the use of a Barkhausen-Kurz tube but was not satisfactory so tried a split anode magnetron developed by Prof. Okabe but this was unstable & by 1932 started his own research. [It should be mentioned here that the Appleton-Ratcliffe experiments on the ionosphere dealing with the Kennelly-Heaviside Layer & polarisation of the transmitted wave were at a wavelength of 400 metres] His younger brother at JRC had made a magnetron based on the drawings of Kyoshi Morita at the Tokyo Institute of Technology & as a result of the interest which this created a special research contract was made between NRI & JRC involving in part the transfer of 5-6 workers from JRC to NRI-JRC apparently had a large staff of some 300 workers involved with the magnetron & finally a device was made in 1939 which was a single phase oscillator at 10cm with 500 w output, water cooled. Yoji using this magnetron, M-3, which included strapped cavities, proposed a collision avoidance system, but this was not successful so arranged to go to Germany to see what they were doing. In January 1940 he went to inspect war preparations in Germany & as he was fluent in German was able to extract information such as that on the Wurzburg radar (made by Telefunken) & information on the pulse work in England which he notified back to NTRI straight away . (Ito was scheduled to be away 2 months but finally took 10 months having to come back by South America). On his return he considered the possibility of atomic weapons , realising that the US had stopped the export of uranium, but as no information had come from Germany & the expected time for the US was expected to be beyond the war, he concentrated on the radar work. [The 2 leading Japanese scientists involved with tentative Japanese nuclear weapons programs were Yoshio Nishina & Bunsaku Arkatsu ,both of whom had significant pre-war contact in the west-in England at Rutherford's Cavendish, Denmark with Bohr & Einstein in Berlin]{In November 1945 the US ordered destroyed 3 Japanese cyclotrons to prevent any possible military use}.

The NTRI followed the Germans at 4.2 metres 5kw & in a crash program by September 1941 detected a bomber at 97 km-this became production Mark 1 Model 1. After Pearl Harbour Ito was promoted to Captain & made head of the Magnetron Dept. at NTRI & apparently was especially pleased with his work on the 1st microwave radar at 25 cm, 2kw (Gekko night fighter). During the war it was the IJN which did all the magnetron work & passed it on to the army.

Shigeru Nakajima completed his Electrical Engineering (Communications) degree at Waseda University & spent a further year studying photo tubes until he was able to take up a position at JRC (Japan Radio Company)in 1931 to further his interest in very high frequency electron tubes which became possible rather than being at Toshiba which apparently held General Electric (Schenectady) patents to expire fairly soon. In 1935 he got something like pleurisy & his doctor suggested equipment for heating muscle tissue which was used in Germany for electromagnetic therapy. Nakajima said he could make the equipment & his company , JRC, found a lucrative market compared to the military & marine products they were making. As a reward for a very profitable order & as JRC had a lot of money, the company president offered to send him overseas to a foreign company for 3 years-but not to Telefunken as the president felt that as Telefunken was under the control of the German military that Telefunken would decline to show him their technology. Nakajima insisted on going to Germany & got permission to go to Telefunken in 1937 in Berlin & spent 1 ½ years studying transmitting vacuum tubes, including zirconium getters (a gas absorbing material in a high vacuum envelope) which technology was not available to Japanese tube makers until Nakajima brought it back.

As mentioned for his brother above, when he returned to Japan the request from Kyoshi Morita was the start of the joint venture between JRC & NTRI. In his oral history of 1994 Nakajima mentions that the Navy was against electronic technology & did not permit the use of precious metals for the magnetron such as cobalt for use in magnets. He also mentions that he would read German technical journals every day & hardly not at US material. It appears that during the war Nakajima continued his work with vacuum tube research.

The defense of the Japanese homeland & the Japanese Army radars.

The problem of duplication in radar effort by the Army & the Navy was a very serious one which was not even started to be looked at until late 1943 with standardisation of at least some components & the 1st joint radar project being the copy of the small German Wurzburg gunlaying set (50cm) . The Army had the predominant role for home defense in Japan & from an Australian point of view its main radar service was thought to be in developing a small number of microwave sets using 13 cm magnetrons to have the flexibility of moving slightly higher if the 10cm & shorter wavelengths used in US radar were jammed by the Japanese. The Army had its own radar research body known as the Tama Institute which did all their own research ,albeit duplicate, except on magnetrons.

The experience of the Japanese in attempting to copy British, American & German radars is worth considering as in all instances the result turned out to be unsatisfactory for the Japanese.

SCR268 200 mc/s gunlaying radar: One working set & other incomplete sets were captured at Corregidor & taken back to Japan for Sumitomo to copy as S-3 which commenced in August 1942.

The air defence of Japan against the B-29's suffered greatly from the lack of gunlaying radar to control mainly the 120 mm AA guns & others, as well as not having an effective GCI set to make fighter intercepts. The lack of a high powered magnetron as already mentioned was the biggest drawback & it is of note to see how this situation arose considering the fairly similar positions of the 10cm magnetron design in Japan & the US/UK in 1940. During the preparation of the Short Survey one set that was developed by the Army that was thought to have considerable interest.

This was a large scale GCI type system (Tachi 28) being installed near Tokyo at the end of the war. It operated on 190 mc/s with a range of 300 km. This complete ground equipment system with an associated airborne equipment, Tachi 30, was to provide reasonably accurate data on the current position of up to 30 controlled aircraft. Each plane transmits a continuous radiating signal on 190 mc/s & 2 or more Direction Finder stations located at intervals of about 50 miles pick up the signals- their antenna rotate steadily at 2 rpm. From the data of both stations an operator can locate a plane quite accurately. This system was of interest to the US in that it provided instantaneous remote indication of a large amount of data on each of the 30 planes. It was intended for GCI use & a large installation was being installed in the Tokyo area but this large scale project was interrupted by the end of the war.

Production was at the rate of 5 /month with an order for 80 sets. The US assessment of these copies was that ‘They had no better luck with these sets in hitting anything as we did with the SCR268” [SCR 268’s arriving in Australia in 1942 more modified to air warning as a cumbersome improvisation].

British SLC Search Light Control: The Japanese after the capture of Singapore obtained a complete set of drawings & specifications for a searchlight or fire control radar. Tachi-1 & Tachi-2 locators were built for the Japanese Army showing British SLC influence at 200 mc/s and in the antenna design.

Small German Wurzburg: Built as Tachi-24 this was a 50cm fire control radar. Plans & key components arrived by submarine in January 1944 (I think an earlier submarine bringing the Wurzburg set may have been sunk). In early 1945 Nihon Musen were commissioned to build 3 model sets of the German Small Wurzburg which were to go to Sumitomo & Tokyo Shibura to go into production. Models began in March 1945 & the 1st set was within 1 month of completion when the war ended. Due to bombing the supply of CRT’s had been delayed. If the Japanese had this set 6 months earlier with its vastly superior tracking accuracy the effectiveness of their (120mm) AA defense might have been very greatly increased resulting in much heavier loss to our B-29 aircraft. As it was the B-29 losses out of 27,261 sorties were : AA action 48, Enemy air action 58, Combined AA & air 29, Unknown causes 79 Total of 214.

US IFF specimens: Good specimens of US IFF were captured from downed B-24’s & B-29’s but these had not been copied it would seem before August 1945.

US 3 cm magnetrons: The Japanese tried unsuccessfully to produce copies of 3 cm magnetrons from renovated APQ-13 airborne sets.

“Rotterdam Gerate”: Japan received by radio telegraph the design specifications of this captured English H2S 10cm radar probably in 1943 & the sets built were scrapped after poor results. (2 were scrapped & 1 sent to the US for examination.

1 in this book for rabaul japan radar type 11

The Imperial Japanese Navy sent nearly one-third of its long-range land-based early warning radar units to defend Rabaul. This unit was one of two installed at Tomavatur Mission, 2 miles southeast of Vunakanau. (AC)