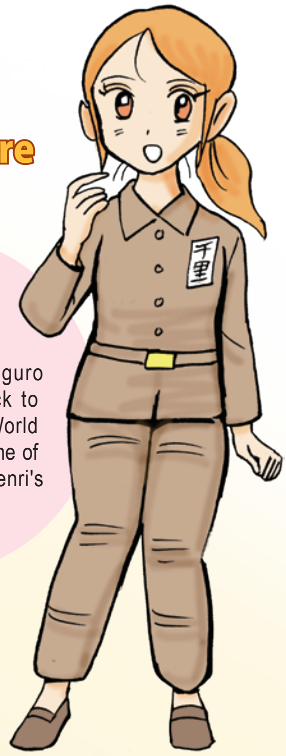
アルマーの冒険 ALMAr
ALMAr's Adventure

Issue 07: Side Story I
"The Start of Japanese Radio Astronomy Investigating the Enigmatic Wartime Large Parabolic Antenna"

Issues 05 and 06 were a two-part set summarizing "The Dawn of World Radio Astronomy" and "The History of Japanese Radio Astronomy." This time is a side story about an enigmatic wartime giant parabolic antenna that was possibly related to the origin of radio astronomy in Japan. The surprising thing is we've learned that the large parabolic antenna was constructed as a weapon to shoot radio waves during World War II.



Tora Senri

This girl helps Dr. Ishiguro when he time-slips back to 1944 in the middle of World War II. Actually, she is one of the Senri line, Nao Senri's great-grandmother.

Mikaduki

This mysterious female cat helps Tora Senri and can understand human speech. She might have some connection to ALMAr and Izayoi who appeared in front of Nao.

Navigator
Dr. Masato Ishiguro
(NAOJ Professor Emeritus)
At the edge of Mansei Bridge in Akihabara, Tokyo

Chapter 7-1: 2017, the Enigmatic Vacuum Tube from Akihabara

★Town of Shimada, Shida District, Shizuoka Prefecture (Now City of Shimada, Shizuoka Prefecture)

Navigator Dr. Masato Ishiguro is a Super Vacuum Tube Collector

Displaying part of Dr. Ishiguro's collection. Just polishing these cute vacuum tubes, he starts to smile without realizing it. He arrays the famous items, rare items, and high quality items (the good mixed with the bad) with various sizes, shapes, and materials. For some reason they include a vacuum tube from Nobeyama Radio Observatory's Nobeyama 45-m Radio Telescope (of course a broken discarded one).

NAOJ Professor Emeritus Masato Ishiguro, who went on to successfully led the construction of the very productive radio astronomy array "ALMA" (and make appearances in ALMAr's Adventure, perhaps in a dual role as Dr. Blackstone), started off as a young boy who loved radios. As a child, he was enthusiastic enough about amateur radio to contribute many articles to hobby magazines. In addition he continues to add to his collection of vacuum tubes accumulated over many years (until it now fills a clothes box). He has quite a varied lineup, from small ones he bought himself to a discarded one he inherited from a high power transmitter for a radio station. The collection includes ones he soldered new connectors to himself and outstanding examples he completely disassembled and overhauled. Allow us to introduce Dr. Ishiguro's vacuum tube collection.

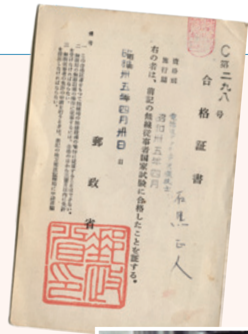
Dr. Ishiguro still makes trips to Akihabara Electric Town in Tokyo. Here he is looking through one of the few remaining vacuum tube specialty shops. "Oh. This is a rare one!"

In a vacuum tube amplifier shop, he has them actually play some music and listens to the tone for a while. "Ah. This is good" he smiles. By the way, he is a big fan of the Asian singer Teresa Teng.

Flashback: The Beginning of Dr. BS's Radio Career

Having lost my father during the war, I grew up at the house of my grandfather, a dentist. Even from elementary school I liked building things, and he let me use various tools for dental treatment to make things. There were many times he'd get mad because in the middle of a dental procedure he'd find that I had taken a tool he needed. To make it up to him I'd help him melt the gold for crowns and use a roller to press it into sheets the right thickness for dental work. Thanks to this, my fingers became dexterous, a great advantage for assembling radios, etc.

Around that time the "3 class" amateur radio operator system started. I knew that even a Jr. high school student could become a radio operator if he passed the State Examinations for Radio Operators, so without waiting I took the first State Examination under the new system. I had real problems on the test. There were questions requiring the computation of resonant frequencies, but as a second year Jr. high school student, I didn't know how to calculate a square root. So on the back of the answer sheet I calculated the squares of numbers until I found the answer by trial and error. I thought I had hopelessly failed, but miraculously I passed the test. I was walking on air when I received my certification (Figure 01).



C第二九八号

合格証書

右の者は、前記の無線従事者国家試験に合格したことを証する。

昭和卅五年四月卅日

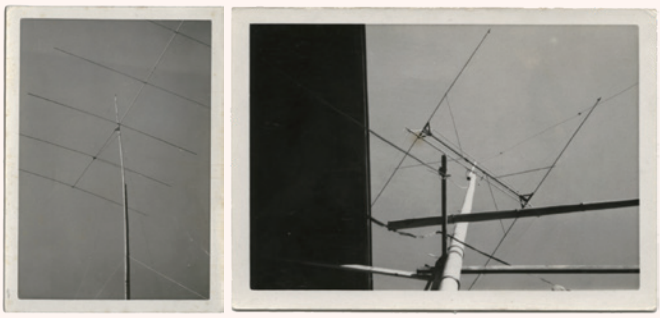
郵政省

01 Passing Certificate from State Examinations for Radio Operators (amateur radio operators) (April 1960).

02 The young Dr. BS and his radio.

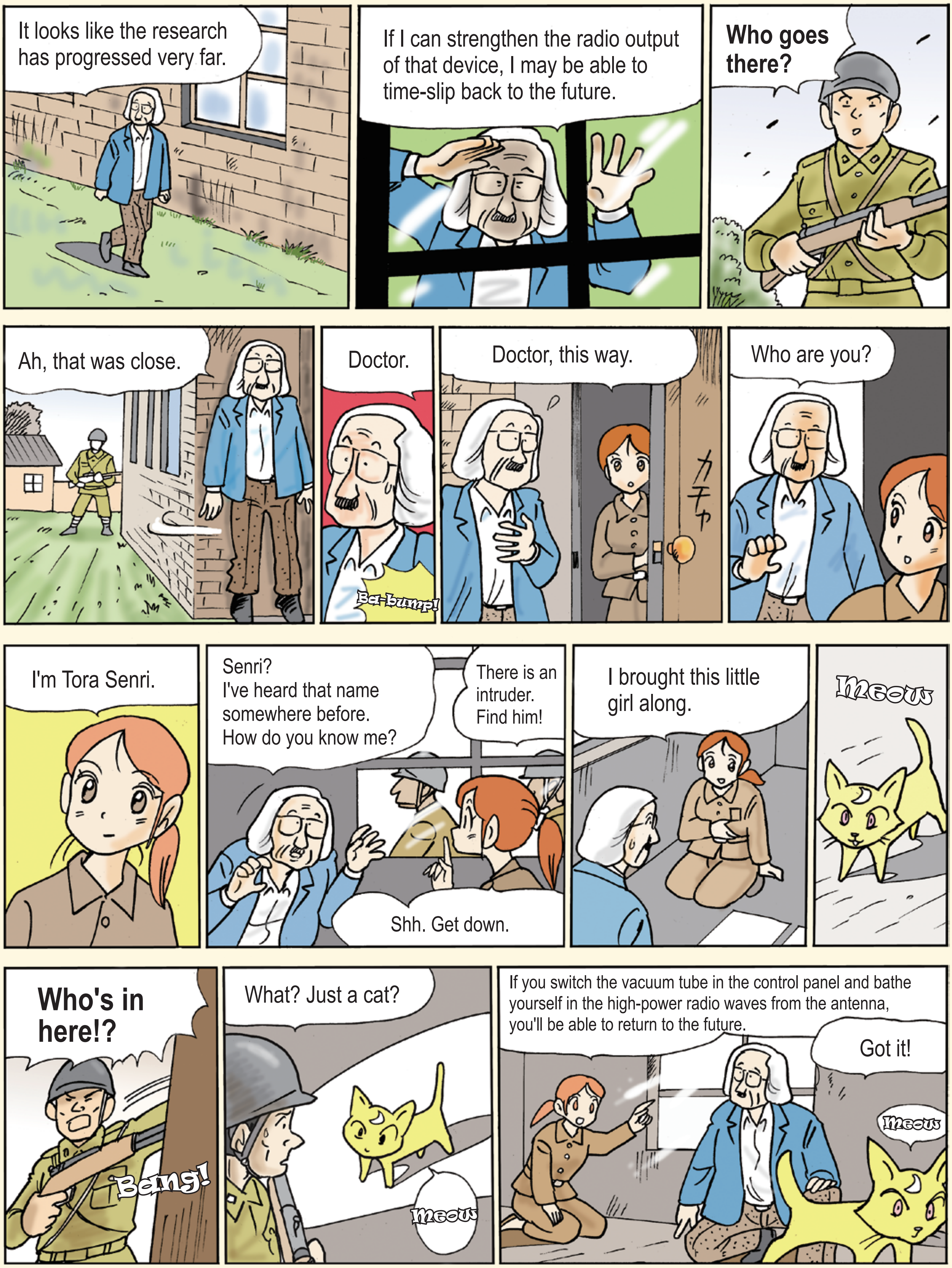
My grandfather had already lost one son who had wanted to become a dentist (my uncle) during the war, so he had high expectations for me. He often took care of the cost of radio components for me. (Ironically, this caused me to drift away from dentistry to radio astronomy.) I gathered junk and hand-built parts, creating my own radio station. I enjoyed communicating with people overseas (Figure 02).

In order to receive the faintest signals possible, and to broadcast my radio signal as far as possible, I built a series of high performance antennas. They were made by connecting aluminum pipes, copper wires, and countless bamboo poles (Figure 03). They were vulnerable to typhoons, and I had to repair them over and over. It was difficult to cross roads where cars were driving while carrying home bundles of bamboo poles over 10 m long on my bicycle. During construction or adjustment, I would often go up onto the second story roof and get scolded when I broke the tiles. I got used to working in high places, so later at Nobeyama and ALMA I could go up the large parabolic antennas without difficulty.



03 (Left) A 6 element Yagi-Uda antenna for 15 m wavelengths (constructed August 1962); (Right) A 2 element loop antenna for 15 m wavelengths (constructed October 1962); after a typhoon struck, I had to construct a new antenna after only two months.

Chapter 7-2: 1944, "Project Z" at the Naval Shizuoka Shimada Laboratory

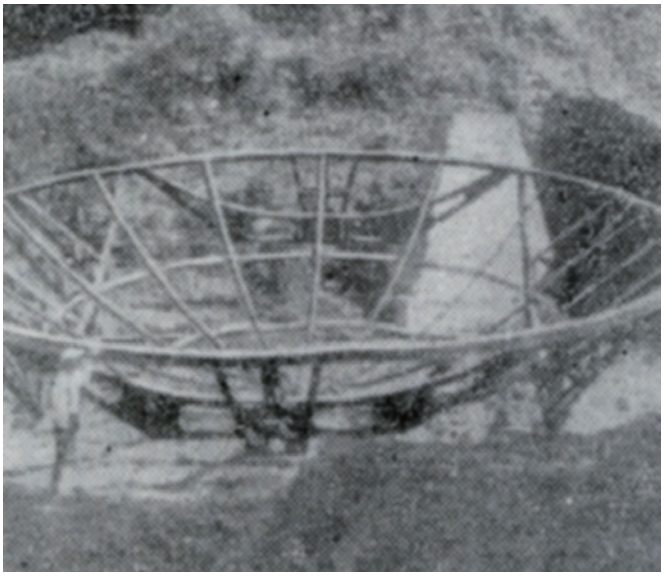


The Enigmatic Large Parabolic Antenna in the City of Shimada, Shizuoka.

The parabolic antenna is indispensable for modern radio astronomy. Where, when, and for what purpose was Japan's first large parabolic antenna constructed?

Japan's First(?) Large Parabola

Dr. Masato Ishiguro is now actively researching the "Start of Radio Astronomy" in Japan (See page 10). As part of those activities, while poring over many documents about the roots of Japanese parabolic antennas, he came across an account of a former research lab belonging to the Japanese Navy. From it, he learned that during World War II, there had been a 10 m parabolic antenna in what is now the City of Shimada in Shizuoka, at a facility known as Ushio Branch Laboratory (Figure 01).



01 The frame of the 10 m reflector left behind on the site of Ushio Branch Laboratory. You can get a feeling of the huge size from the person standing on the left side. (Chunichi Topics, January 1950 "Death Ray Report") ★

But records remain showing that this parabolic antenna wasn't used as a radio telescope; it was built as a prototype for a weapon. The name was Project Z. Fearing that Japan was losing during World War II, the Navy gathered scientists and engineers to conduct top-secret research aimed at delivering a crushing blow to the United States military. The list includes many distinguished scientists like Yusuke Hagiwara, who would later serve as the Director General of Tokyo Astronomical Observatory; Minoru Oda who developed a modulation collimator for an X-ray telescope; and even future Nobel laureates in physics Hideki Yukawa and Sin-Ichiro Tomonaga (Figure 02).

Project Z used special vacuum tubes known as magnetrons to generate intense microwaves (the same mechanism used in modern microwave ovens) as a weapon to irradiate enemies. The intent of this electromagnetic weapon was to point the parabolic antenna at an airplane in flight and irradiate it, melting the airframe and interfering with the instruments to cause the enemy aircraft to crash. But only a couple of years after the research started, the war ended before it could be completed. For this reason it is referred to as a phantom weapon.

02 The scholars and students assembled at Shimada Laboratory. In the center of the first row is Yusuke Hagiwara, the future Director General of Tokyo Astronomical Observatory. To the right are Hideki Yukawa and Sin-Ichiro Tomonaga. Minoru Oda is 3rd from the left in the back row. ★

Project Z's Base in the City of Shimada, Shizuoka

Ushio Branch Laboratory where Project Z was conducted is located on the slightly elevated Mt. Ushio overlooking the adjacent Oi River in the City of Shimada, Shizuoka. The facilities were closed at the end of the war. After that, the vacant structures remained for many years, but recently the site was removed as part of construction to widen the channel of the Oi River. It was literally leveled (Figure 12).

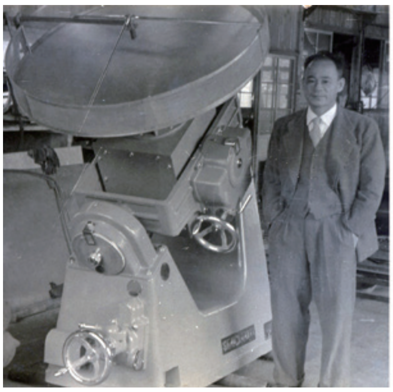
Before the historical site was lost, a thorough investigation was conducted. The City of Shimada Board of Education excavated the site from 2013 to 2014. On the overgrown site they found multiple ruins identified as the foundations for buildings and various items used at that time were unearthed. Then in 2015, for the 70th anniversary of the end of the war, Shimada City Museum hosted an exhibit "Shimada and the Pacific Theater." It seems the naval facilities near Shimada were also introduced in this exhibit.

Shimada and Yaizu and Sojiro Norizuki

When talking about Shimada, we must mention that it is right next to Yaizu City Shizuoka where Sojiro Norizuki (Figure 03), whom we introduced last time (ALMAr's Adventure Issue 06), was born and raised. Starting from just after World War II he was commissioned by the Nagoya University Research Institute of Atmospherics and Tokyo Astronomical Observatory (both forerunners of NAOJ) to make many radio and optical telescopes for research and public stargazing.

Norizuki got his start in telescope fabrication from meeting Dr. Haruo Tanaka of the Nagoya University Research Institute of Atmospherics (Figure 04). After the end of World War II, around 1948, Norizuki took a job at SPC Electronics Corporation in the neighboring town of Shimada. It was at SPC Electronics that he had his fateful meeting with Dr. Tanaka. One day, Dr. Tanaka visited SPC and asked them to manufacture a parabolic antenna radio telescope, but he couldn't pay very much so they refused the job. Norizuki heard this and thought, "I'll give it a try" so volunteered to make it. This is how his relationship with the Research Institute of Atmospherics got started.

Coincidentally, SPC Electronics was founded as "Shimada Rika Kogyosho" at the end of 1946, shortly after the end of the war (1945). Now the company has moved to Tokyo where it manufactures communication systems and high frequency heating equipment. But before that, it was located at the Second Naval Technical Institute's Shimada Laboratory which had previously been involved in weapon research. It is said that after the war, Mr. Shoichiro Mizuma, the vice director of Shimada Laboratory had said to the other 20 people, "Let's apply our research to peace-time industry" and reorganized the laboratory as Shimada Rika Kogyosho.

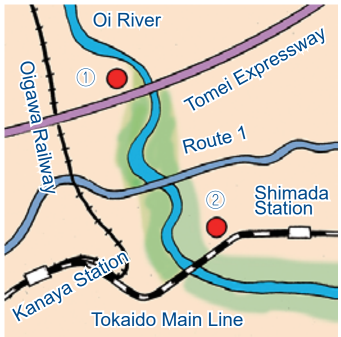


03 (Left) Sojiro Norizuki (1957, pictured with a telescope commissioned by Tokyo Astronomical Observatory)
04 (Right) Dr. Haruo Tanaka (1951, pictured with Japan's first equatorial mount parabolic radio telescope)

★ Figures 01 and 02 are from the "Reports of Buried Cultural Properties of the City of Shimada, Shizuoka, Issue 49 - Report of buried cultural assets excavated at the ruins of the Second Naval Technical Institute's Ushio Branch Laboratory by the river channel widening work in the Ushio section of the Oi River."

Digging a little deeper, Dr. Ishiguro learned that Ushio Branch Laboratory had been established as an evacuation location for Shimada Laboratory as the Allied air raids intensified. Dr. Ishiguro feels that the 10 m parabolic antenna, Ushio Branch Laboratory, Shimada Laboratory, SPC Electronics, and Norizuki are all connected in a continuous chain. If they are all related, the Ushio Branch Laboratory 10 m parabolic antenna would have special significance when discussing the history of Japanese radio telescopes.

So feeling that he needed to see the excavated artifacts from the Ushio Branch Laboratory and talk with the people who organized the Shimada City Museum exhibit, Dr. Ishiguro went to the site. While compiling the article about Norizuki, which was published in ALMAr's Adventure Issue 06, he received much research material from Discovery Park Yaizu which has an 80-cm optical telescope fabricated by Norizuki. The astronomy staff member Ayumi Matsunaga served as the window to make that possible. Matsunaga organized the exhibit about Norizuki and requested a lecture by Dr. Ishiguro. In this way she was part of this investigation from the beginning.



05 Map showing the sites of Ushio Branch Laboratory ① and Shimada Laboratory ②.

Shimada Laboratory and Ushio Branch Laboratory

As the investigations progressed, documents came to light showing that in addition to the 10 m antenna assumed to have been located at Ushio Branch Laboratory, there was also a 10 m parabolic antenna at Shimada Laboratory.

Multiple Large Antennas

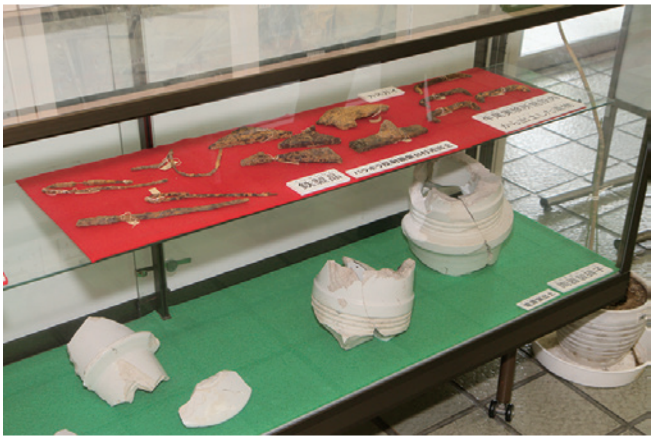
Onsite, Dr. Ishiguro first visited Ryuichi Sakamaki of the City of Shimada Board of Education (Leader of the Continuing Education Division, Department of Education) and Michito Shinogaya (responsible for buried cultural properties in the Cultural Properties Section of the Culture Group) at the Kanaya Office of the City of Shimada (Figure 06, taken November 2016). Sakamaki had been at the Shimada City Museum until the previous year, and had participated in the excavation of Ushio Branch Laboratory conducted from 2013 to 2014. "There are many ruins around Mt. Ushio. In Shizuoka Prefecture, wartime sites were not recognized as well-known ruins, and have been excluded from surveys. But because of its strategic value, we had Ushio Branch Laboratory acknowledged as a ruin and conducted an excavation. At that time I was at Shimada City Museum so I compiled the reports and led the excavations with the goal of putting the unearthed items on display in the museum." So he had a hand in writing the " Reports of Buried Cultural Properties of the City of Shimada, Shizuoka, Issue 49 - Report of buried cultural assets excavated at the ruins of the Second Naval Technical Institute's Ushio Branch Laboratory by the river channel widening work in the Ushio section of the Oi River" which became a 140 page report published in 2015.

Also because the unearthed artifacts are kept in the Kanaya Office, Shinogaya (who manages the buried cultural properties), also attended the meeting. Some of the excavated artifacts were displayed in the lobby of the Kanaya Office, and Shinogaya showed Dr. Ishiguro many additional relics (Figure 07).

According to Sakamaki, "As you already know, the site of the Ushio Branch Laboratory has already been leveled as part of the Oi River channel widening work. Even the remaining foundations of the buildings and what we believe was the mount of the 10 m main reflector (parabolic antenna) are gone now." When Dr. Ishiguro mentioned that "According to the records, they seem to have conducted an experiment where they projected radio waves from the parabolic antenna and cooked a rabbit to death." Sakamaki responded, "That was at Shimada Laboratory." Which means that in addition to Ushio Branch Laboratory, there must also have been a 10 m parabolic antenna at Shimada Laboratory!

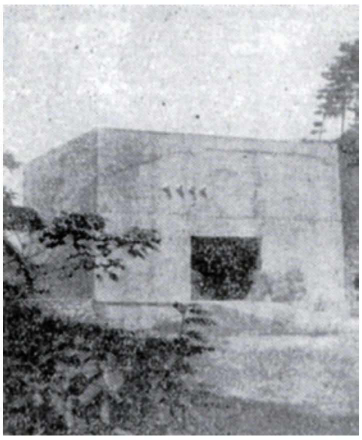
"Near the end of the war, the air raids around Shimada intensified. Preparations were made to evacuate from Shimada Laboratory to two sites, Mt. Ushio and Sakidaira. Mt. Ushio was 4 km north of Shimada Laboratory, on the banks of the Oi River. For Sakidaira, they planned to use the tunnel to Oi River Power Station as a research laboratory. At Ushio Branch Laboratory, they hurriedly demolished a ridge and built buildings and facilities. But we believe it sat unused until the end of the war in August 1945. It is thought there must have also been a 10 m reflector (parabola) at Shimada Laboratory. Shoichiro Mizuma, the vice director at that time, left us sketches recalling the appearance of Shimada Laboratory, and a reflector is depicted in those sketches. Photographs taken after the war show what we think is the mount for such a reflector. There are rumors that there was also an 11 m reflector in Sakidaira, but they are unconfirmed. It seems that one tank and a reflector were transported to Sakidaira, but no documents remain, so we have no idea about their post-war removal."

06 At the Kanaya Office of the City of Shimada (left) Dr. Ishiguro spoke with Ryuichi Sakamaki (right picture, center) and Michito Shinogaya (right picture, right side). As people familiar with the sites, they imparted valuable information. Unfortunately they couldn't provide any confirmation of the connection between the Navy's parabolic antenna and later radio astronomy.



07a Several characteristic relics unearthed at the Ushio Branch Laboratory site displayed in the entrance of the Kanaya Office (November 2016, currently the display is suspended). These ceramic insulators found near the power supply room are gigantic, indicating that the research used strong electrical currents.

07b Dr. Ishiguro picks up a glass insulator and inspects it. "It's cracked, but this is a beautiful insulator. It has been very well preserved."



07c Photo believed to show the oscillator building at Ushio Branch Laboratory (See page 09). ★

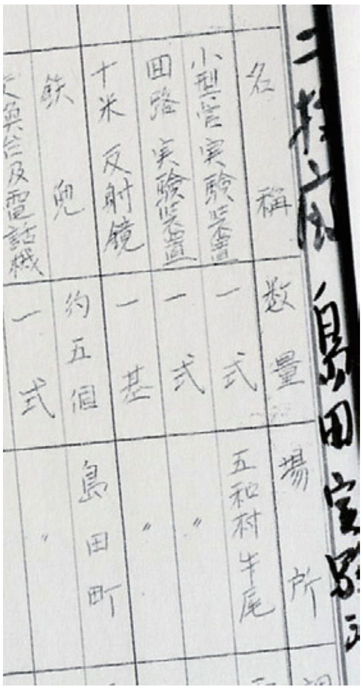
Antenna Production was at Numazu?

Chronologically, the first 10 m parabolic antenna was erected at Shimada Laboratory. Next, a similar parabolic antenna was transported to Ushio Branch Laboratory where it seems to have sat uncompleted until the end of the war. Because Ushio Branch Laboratory was an evacuation site, there is some thought that the Shimada Laboratory antenna was transferred to there. But according to an investigation by Prof. Yutaka Kawamura at the National Institute of Technology, Tokyo College, Uchiro Asano who was a Captain in the Navy (at the end of the war) later recalled that "At Numazu, we made two 10-m reflectors as well as seven 2-m reflectors." At that time there was a facility known as the Navy Engineer School at Numazu.

"Perhaps the reflectors were manufactured in Numazu and then transported to Shimada." conjectures Sakamaki. "After the war a '十米反射鏡' (10-m reflector) is recorded on the transfer invoice made for Ushio Branch Laboratory when it was seized by the Allied Powers General Head Quarters, so its existence can be confirmed (Figure 08). We have eyewitness testimony that after that, the reflector was dismantled and brought down from the Mt. Ushio ridge as a bare skeleton. There are those in the local history research group who say that it might have been repurposed as an astronomical observatory antenna after that, but it is unclear whether or not that was really the case."

At some point, the 10 m parabolic antenna disappeared without a trace. It might have been washed away in a flood. Or there was a time when metal was scarce, so someone might have carried it off. Regarding the antenna at Shimada Laboratory, there is a "10-m reflector" entry on the transfer invoice, but we don't know what happened to it after that. It is completely unknown where the seven 2-m parabolic antennas manufactured at Numazu were delivered and what happened to them after the war.

07d The many unearthed artifacts have been neatly sorted. "There are many items which we don't know what they were used for, but we'd like to continue the investigation in the future." explains Shinogaya. Pictured from left to right: Shinogaya, Sakamaki, Dr. Ishiguro, and Matsunaga.



名称	数量	場所
小型管実験装置	一式	五和村牛尾
回路実験装置	一式	〃
十米反射鏡	一基	〃
鉄塔	約五個	島田町
交換台及電話機	一式	〃

08 A postwar invoice for items surrendered to the U.S. military including a '十米反射鏡' (10-m reflector). ★

★ Figures 07c and 08 are from the " Reports of Buried Cultural Properties of the City of Shimada, Shizuoka, Issue 49 - Report of buried cultural assets excavated at the ruins of the Second Naval Technical Institute's Ushio Branch Laboratory by the river channel widening work in the Ushio section of the Oi River."

09 Dr. Ishiguro speaking with military history expert Asahina. Asahina seems to have conducted studies with local history researchers. He recounted many interesting episodes not limited to the Navel Laboratory.

10 Matsunaga, Asahina, and Ishiguro in front of the museum. The former Shimada Laboratory was located very close to the Museum. Now the site is paper-manufacturing company factory.

The State of the City of Shimada during World War II

Continuing on, Dr. Ishiguro then visited Taro Asahina, who had been Shimada City Museum's chief curator for the "Shimada and the Pacific Theater" special exhibit hosted in 2015 (Figure 09). Asahina had also been responsible for compiling a pictorial record of the special exhibit.

Asahina explained, "In the pictorial record, I wrote the parts about evacuated children and the situation in the city during the war. Director Sakamoto was responsible for the part about Mt. Ushio."

Dr. Ishiguro asked, "Records indicate that many people who went on to be famous scientists worked at Shimada Laboratory. It seems that after the war, documents about the research they conducted were burned and many research devices were destroyed. But how much do you know about the situation at that time?"

Asahina answered, "There were many undergraduate and graduate students who conducted the research. There are indications that everyone was lodged at the temple in town, but faced with the end of the war in August 1945 they seem to have fled back home. I've heard that no one said a word of thanks to the temple that hosted them. It's thought that since they knew about the content of the research, they were probably afraid they would be arrested by the Allied Powers General Head Quarters. Most of the documents were also burned. The only information about the situation of that time we have is what we have heard from local elderly people. We don't know the details of the research."

"We don't know if it's true or not, but we have testimony from elderly people that the researchers would visit the public baths in Shimada and while they were soaking in the water you could hear them wondering 'if the research we're working on will ever be realized.' The witnesses were only children at the time, so they didn't really understand. I was very surprised to hear later that Nobel Laureate Hideki Yukawa had also been here!" (★ Footnote)

The U.S. military dropped a pumpkin bomb on the City of Shimada in August 1945, causing mass causalities. There is a compelling theory that the arsenal in Toyama was the actual target of the air raid but was cloudy, so they dropped the remaining bombs on Shimada rather than carrying them home. After the U.S. military captured Tinian Island, large B29 bombers could target the main Japanese Islands. We know that B29s used the Oi and Tenryu Rivers as landmarks and followed them inland. We also know that they targeted every city. It follows that in cases where the weather over the target was bad and they couldn't drop their bombs, they would aim for cities on the way home, like Shimada or Hamamatsu.

Asahina explained, "There is also a theory that the Shimada air raid happened because Shimada Laboratory was located here. But it seems like actually the American forces didn't know about the military research being conducted here. The pumpkin bomb fell a little ways away from the urban area so Shimada Laboratory escaped damage (Figure 10)."

Standing on the Site of Ushio Branch Laboratory

Mt. Ushio where Ushio Branch Laboratory had stood jutted out as a spur in the Oi River. It was the narrowest part of the river in this vicinity. It is thought to have been the source of devastating floods resulting from heavy rains in the past. Due to concerns over future flooding, work was carried out starting from the end of 2015 to remove the hill and widen the river. Currently (2016), the part where the Ushio Branch Laboratory parabolic antenna and its power supply room had stood is gone, leaving just a flat extension of the river bank (Figures 11 - 16).

The ridge of Mt. Ushio is relatively smooth and is now covered with tea plantations. We traversed the tea plantations to the place where Ushio Branch Laboratory had been, but it was not easy to spot traces of the facility in the woods.

11 A photograph of the river channel widening work taken from the bank opposite of Mt. Ushio. The part jutting out into the river is being chipped away leaving effectively level ground.

12 Looking down at the Oi River area from Mt. Ushio. A vast amount of soil has been removed as part of the river channel widening work.

★ Footnote: According to the records, Dr. Hideki Yukawa attended conferences in Shimada, and there is a high probability that from time to time he posed for commemorative photos (Figure 02). Because it was Sin-Ichiro Tomonaga who was permanently stationed in Shimada at that time, we cannot rule out the possibility of misunderstanding on the part of the witnesses.

Closing the Shimada Investigation

I investigated the area around the City of Shimada in search of Japan's first large parabolic antenna, but in the 70 years since the war, the antenna has been lost and even the site where it is thought to have stood has been erased by development. I was unable to confirm any direct link between Sojiro Norizuki, who manufactured many radio telescopes, and the parabolic antenna constructed in Shimada. If the opportunity arises, I would like to continue this investigation in the future.

Excavation of Ushio Branch Laboratory (2013-2014)

13 (above) The mount for the parabolic antenna, photographed during the 2013-2014 excavation. It seems that at Shimada Laboratory and Ushio Branch Laboratory, the azimuthal direction of the parabolic antenna mount was fixed and only the altitude pointing was adjustable (Refer to page 2 of the comic). These ruins have now been demolished to level ground as shown in Figure 12.

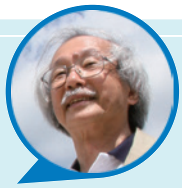
14 (upper right) Overview of the Ushio Branch Laboratory Ruins
Excavations uncovered foundations. The parabolic antenna mount is located in the back left. The square foundation in front of that is thought to have been the site of the oscillator building. And the large rectangular foundation in front of that is thought to have been the site of the power supply room.

15 (lower right) Diorama Reconstruction of the Ushio Branch Laboratory
This "Diorama Reconstruction of the Ushio Branch Laboratory" was created based on the results of the excavation and an investigation of many documents. The sturdy concrete box-shaped oscillator building is next to the Quonset hut shaped power supply room. It is thought that the parabolic antenna was positioned at the edge of the ridge. This reconstruction diorama was produced as a Shimada Technical High School Architecture Department graduation project.

16 It is thought that the Ushio Branch Laboratory parabolic antenna was planned to be erected facing upstream along the Oi River. (This photo was taken facing upstream along the Oi River from the top of the modern Mt. Ushio.) There is some thought that this was so it could be aimed at U.S. military B29 bombers using the Oi river as a landmark and following it upstream to target cities. Based on records left behind, it was determined that the microwaves projected by the parabolic antenna would have been insufficient to down an airplane directly, so research was conducted to investigate the possibility of firing munitions primed with a detonator from a large caliber cannon and using the radio waves projected from the parabolic antenna to detonate the shells midair near the airplane.

★ Figures 13, 14, and 15 are from the " Reports of Buried Cultural Properties of the City of Shimada, Shizuoka, Issue 49 - Report of buried cultural assets excavated at the ruins of the Second Naval Technical Institute's Ushio Branch Laboratory by the river channel widening work in the Ushio section of the Oi River."

The First Radio Astronomy Observations in Japan



Author: Dr. BS (Blackstone)

★ Also known as Dr. Masato Ishiguro
(NAOJ Professor Emeritus)

How did Radio Astronomy Observations in Japan get started?

In 2009, I became the Japanese member of the IAU (International Astronomical Union) Historic Radio Astronomy Working Group. It provided me an opportunity to review the history of Japanese radio astronomy (focusing on pre-1960). With the help of the Former-Chair Wayne Orchiston and others I have published 5 papers to date (References 1, 8, 11, etc.). As part of these activities, I reinvestigated the dawn of Japanese radio astronomy observations, particularly the very first radio astronomy observations.

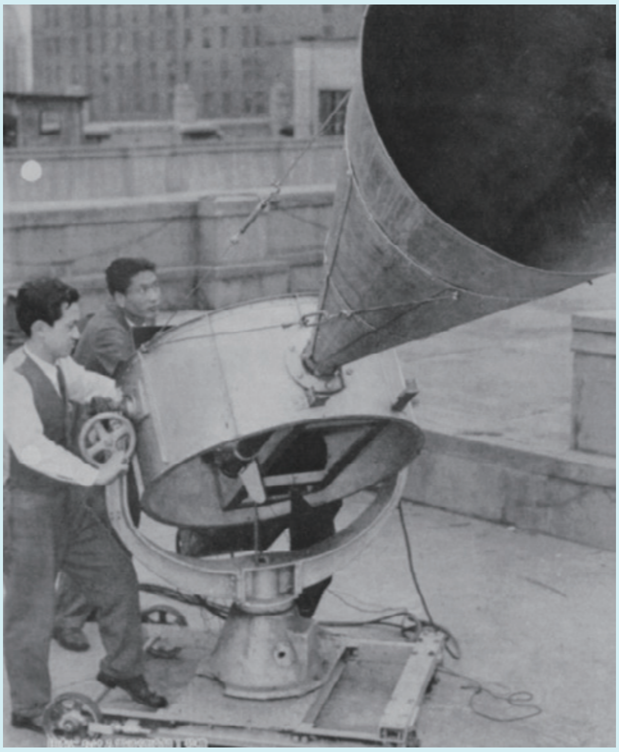
In the process of digging through the piles of material, I found the following three important documents. The first was "Haruka Story" (Reference 2) contributed to ISAS News by Minoru Oda (deceased). Among the old stories from the region that nurtured Japanese radio astronomy it states, "Koichi Shimoda (then at the University of Tokyo) observed solar radio waves during a partial solar eclipse using an old military audio tracer consisting of copper plates affixed to a wooden parabolic frame. This probably was the only meaningful observation conducted at that time." Furthermore in his compilation presented at the "Twenty-First Century Science and Technology Symposium" Muses speculates, "Shimoda used a military audio tracer because at that time, he wouldn't have been able to make a parabolic antenna from scratch. So he fitted copper plates or something over an audio tracer to make a parabola and actually observed solar radio wave variations during a partial solar eclipse. We could call him the founder of Japanese radio astronomy."

Dr. Shimoda is famous in the fields of lasers and quantum electronics (Figure 01). Investigating Shimoda further, I received a very important document from Kenji Akabane (now deceased). The document was "Two Reflectors made in 1930" (Reference 4) presented as the After Dinner Talk at the 13th Okazaki Conference and published as an English report IMS Letters. This report presents the data from the above mentioned solar eclipse observations; I also learned that the day observations were conducted was May 9, 1948. Kenji Akabane also introduces this material in an article in Japanese Scientific Monthly (Reference 5).

01 A young Koichi Shimoda.

In microwave observations, Shimoda was even earlier than Oda and Takakura

The only English language report introducing Japanese radio astronomy (particularly solar radio astronomy) up to now was a report (Reference 6) by Haruo Tanaka (deceased) about Japanese solar radio astronomy up until 1960 published in 1984 in a book edited by W.T. Sullivan III. According to this report, the 3.3 GHz observations by Oda and Tatsuo Takakura (deceased) in November 1949 were the first Japanese observations of solar radio waves at microwave wavelengths. On this topic we have an article by Takakura in the Astronomical Herald and the cover photograph "The First Radio Telescope in Japan" (Figure 02). But Shimoda's solar eclipse observations were more than a year before Oda and Takakura's observations. It is curious that there wasn't one word about Shimoda's observations in either Tanaka's report or Takakura's Astronomical Herald article.



02 In November 1949 Minoru Oda and Tatsuo Takakura conducted an experiment to capture solar radio waves at 3.3 GHz (cover of the June 1985 Astronomical Herald).

We know that Shimoda was alive and active after that. In December 2011, I had a chance to visit him at his home in Kichijoji, with Takashi Kasuga (Hosei University) who had studied in Shimoda's laboratory, and speak directly with him. He showed me the lab book from that time. It included experiment circuit diagrams and detailed compilations of experimental data. I marveled at Shimoda's outstanding ability to process information. At that time there weren't even chart recorders for recording data. Data displayed on a cathode-ray tube was copied by hand onto tracing paper. I can understand how difficult it must have been. He also showed me actual crystal detectors used at that time (Figure 03). I knew there were no published reports describing the results of this historic experiment. I received Shimoda's consensus to publish these results as part of a report series about the history of Japanese radio astronomy. And in 2013 a report was finally published (Reference 8) describing in detail the state of observations at that time.

03 Crystal detectors used by Koichi Shimada in radio observations of the May 9, 1948 solar eclipse.

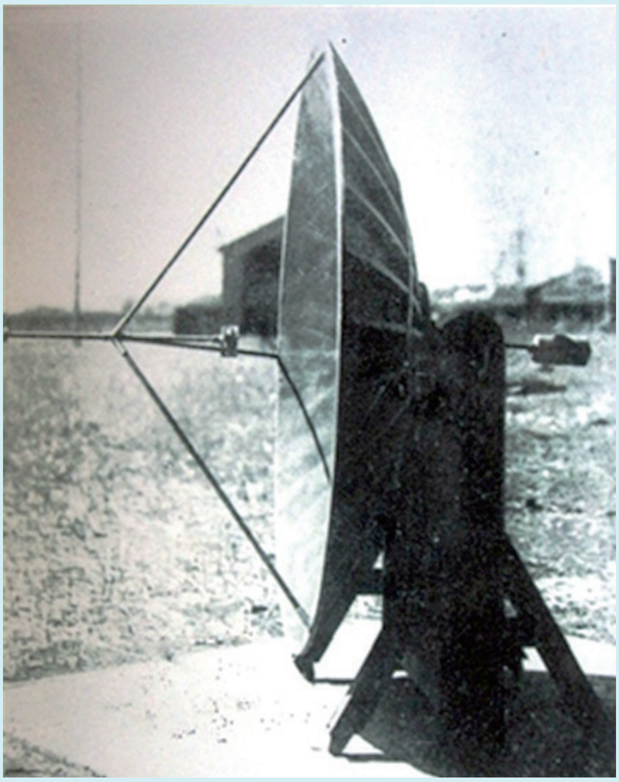
In his book (Reference 9) Shimoda has the following to say about these crystal detectors, "I started performing experiments to see whether or not the crystal radio wave detectors I made when I was in elementary school were sensitive to microwaves as well. I investigated the detection sensitivity of models using crystals like galena, pyrites, bornite, then silicon carbide or silicon until December 1943. ... [passage omitted] ... Then I tried using one of those crystal detectors as a mixer (frequency converter), and the next year in March 1944, I completed a microwave superheterodyne receiver using a magnetron as the local oscillator."

At that time Shimoda was a graduate student fellow involved in radar research at the Technical Research Institute of the Japanese Navy (reference 10). This research might have led to Japan's first microwave observations of a solar eclipse.

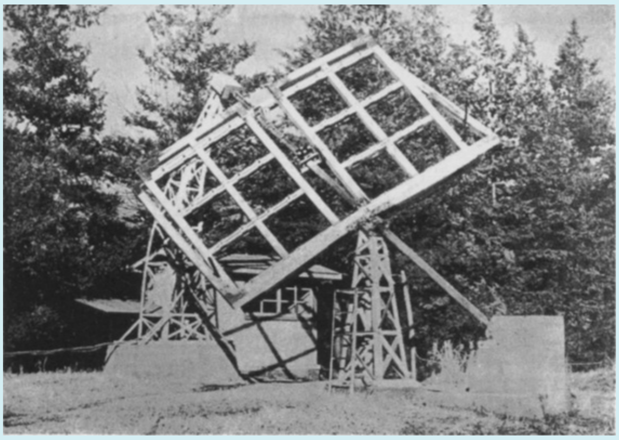
The Commencement of Meter-Wave Radio Wave Observations at Tokyo Astronomical Observatory

In an interview article for the Japan Society of Applied Physics (Reference 10), in a chapter titled "This is how Japanese Radio Astronomy got Started" Shimoda describes the May 9, 1948 partial solar eclipse observations. "For the parabolic antenna, I used one which had been used by Prof. Juichi Obata as an acoustic instrument for collecting sound, with a 2 m diameter made by attaching copper plates to a wooden frame (Figure 04). At that time, Takeo Hatanaka at the Tokyo Astronomical Observatory Mitaka Campus had used an antenna made by connecting two pieces of wire in a cross shape to observe meter-waves from the Sun. No one had yet succeeded in observing 10 cm wavelengths, so I gave it a try."

Which would mean that at Tokyo Astronomical Observatory (the precursor of NOAJ), solar radio observations were conducted before the completion of the 200-MHz solar radio telescope discussed below. Unfortunately, I was not able to find any documents related to these observations. If this is true, it means that Japan's first radio astronomy observations were the solar observations at meter wavelengths conducted by Taeko Hatanaka (deceased). The first radio telescope at Tokyo Astronomical Observatory



04 The 2 m aperture parabolic antenna (repurposed military audio tracer) used by Koichi Shimoda for radio observations of the May 9, 1948 solar eclipse.



05 The 200 MHz radio antenna constructed at Tokyo Astronomical Observatory (Mitaka). Continuous observations of solar radio waves began in September 1949.

06 The solar radio telescope (with a parabolic antenna received from Shimoda) erected by Kenji Akabane at Tokyo Astronomical Observatory (Mitaka) in 1951.

was the 200 MHz solar radio telescope (Figure 05) constructed by Hatanaka and others with the help of the Radio Physics Laboratory in 1949; and it started observations September of the same year (100 Years of the University of Tokyo, Vol 3, page 43). This would also have been before Oda and Takakura's November 1949 observations.

In any case, we can say that 1948~1949 was an extremely important time in the early history of Japanese radio astronomy. We can image how difficult it must have been to conduct research while unable to obtain sufficient parts in the post-war confusion. The parabolic antenna Shimoda made was given to Akabane in 1951 and was used at Mitaka Campus for microwave (3 GHz) solar observations (Figure 06, Reference 11). And in April of the same year, at the Nagoya University Research Institute of Atmospherics located in Toyokawa City Aichi Prefecture, Tanaka constructed a 2.5 m aperture parabolic antenna, Japan's first equipped with an equatorial mount, and began regular observations of solar radio waves at 3.75 GHz. This was a period when Japanese radio astronomy really got going (References 1, 6).

Lost Credit for Discovery of Solar Radio Waves

Finally, I'd like to introduce the possibility that Japan might have been the first to discover solar radio waves. This was on August 1, 1938, four years before J. Hey et al. discovered solar radio waves in 1942. Minoru Nakagami (deceased) and Ken-ichi Miya (deceased) at International Telecommunication Co. Ltd. suddenly had the noise increase rapidly, by a factor of 10,000 to 100,000 times, during observations of the Dellinger Phenomenon and they determined that the noise was coming from the sky with an elevation angle of over 70 degrees (Reference 12).

"IX. Radio Astronomy" by Haruo Tanaka et al. in "Trends in Radio Engineering Research" (Reference 13) says that "As the sun was then placed at about 70 degrees in elevation angle, Miya believed naturally that the noise came directly from the sun. However, his senior Nakagami was too cautious to accept the young Miya's simple idea, and imagined that the noise originated around the E-layer, connected with a Dellinger disturbance of the ionosphere. In the end the possibility of direct noise from the sun was not mentioned in their paper." Reference 6 says the same thing, but in English, making this information available to researchers worldwide.

It is difficult to believe that the monitored signal increased by a factor of 10,000 or 100,000 in a short time due to an anomaly in the ionosphere. There is a high probability that this was a radio burst accompanying a solar flare. If the possibility that these abnormal radio waves might have been of solar origin had been properly reported, credit for the discovery of solar radio waves might have gone to Japanese researchers.

Acknowledgements: Searching for documents about research that occurred over 60 years ago is a very difficult job, but it was made possible thanks to the help of NAOJ Library Librarian Junko Oguri. Here I would like to take the space to thank her.

【Reference Documents】

1) Ishiguro, M., Orchiston, W., Akabane, K., Kaifu, N., Hayashi, M., Nakamura, T., Stewart, R., and Yokoo, H.: 2012, Highlighting the history of Japanese radio astronomy. 1: An introduction, Journal of Astronomical History and Heritage, 15, 213-231.
2) 小田稔 : 1999, はるか物語 , ISAS ニュース , No.221.
3) 小田稔 : 2001, リンクスの目・リンクスの耳「21世紀の学術と科学技術」（伏見康治 , 中井浩二 , 見角鋭二 , 菅沼純一編）, 45-51.
4) 霜田光一 : 1982, Two Reflectors made in 1930, 分子研レターズ　No.10.
5) 赤羽賢司 : 1990, 電波望遠鏡 , 学術月報 , 43, 545.
6) Tanaka, H.: 1984, Development of solar radio astronomy in Japan up until 1960, in Sullivan, W.T. III(ed.), The Early Years of Radio Astronomy: Reflections Fifty Years after Jansky. Cambridge, Cambridge University Press, 335-348.
7) 高倉達雄 : 1985, 太陽電波とともに35年 , 天文月報 , 78, 163-166.
8) Shimoda, K., Orchiston, W., Akabane, K., and Ishiguro, M. : 2013, Highlighting the history of Japanese radio astronomy. 2: Koichi Shimoda and the 1948 Solar Eclipse, Journal of Astronomical History and Heritage, 16, 98-106.
9) 霜田光一 : 歴史をかえた物理実験 , パリティブックス（丸善出版）
10) 霜田光一 : 2007, メーザー , レーザーと物理教育 , 応用物理 , 76, 872-878.
11) Nakajima, H., Ishiguro, M., Orchiston, W., Akabane, K., Enome, S., Hayashi, M., Kaifu, N., Nakamura, T., and Tuchiya, A. : 2014, Highlighting the history of Japanese radio astronomy. 3: Early Solar Radio Research at the Tokyo Astronomical Observatory, Journal of Astronomical History and Heritage, 17, 2-28.
12) 仲上稔 , 官憲一 : 1939, Dellinger 現象出現時に於ける短波長電波ならびに短波帯に発生する雑音の入射角に就いて , 電気学会雑誌 , 59, 176.
13)「電波工学研究の動向」調査報告書 No.2: 文部科学研究費補助金特定研究（1）, 学術研究動向の調査研究電波工学斑（1983）

A Visit to Discovery Park Yaizu

The last astronomical telescope handled by Sojiro Norizuki was the 80 cm diameter equatorial mount reflector telescope installed at Discovery Park Yaizu. At Discovery Park Yaizu there is a mini-exhibit displaying the tools and such used by Norizuki.

01 The 8 m diameter silver dome, which appears in the pine trees as you travel south from the Yaizu city center towards the coast, marks the location of Discovery Park Yaizu. Of course there aren't any city lights on the seaward side, providing excellent conditions for stargazing.

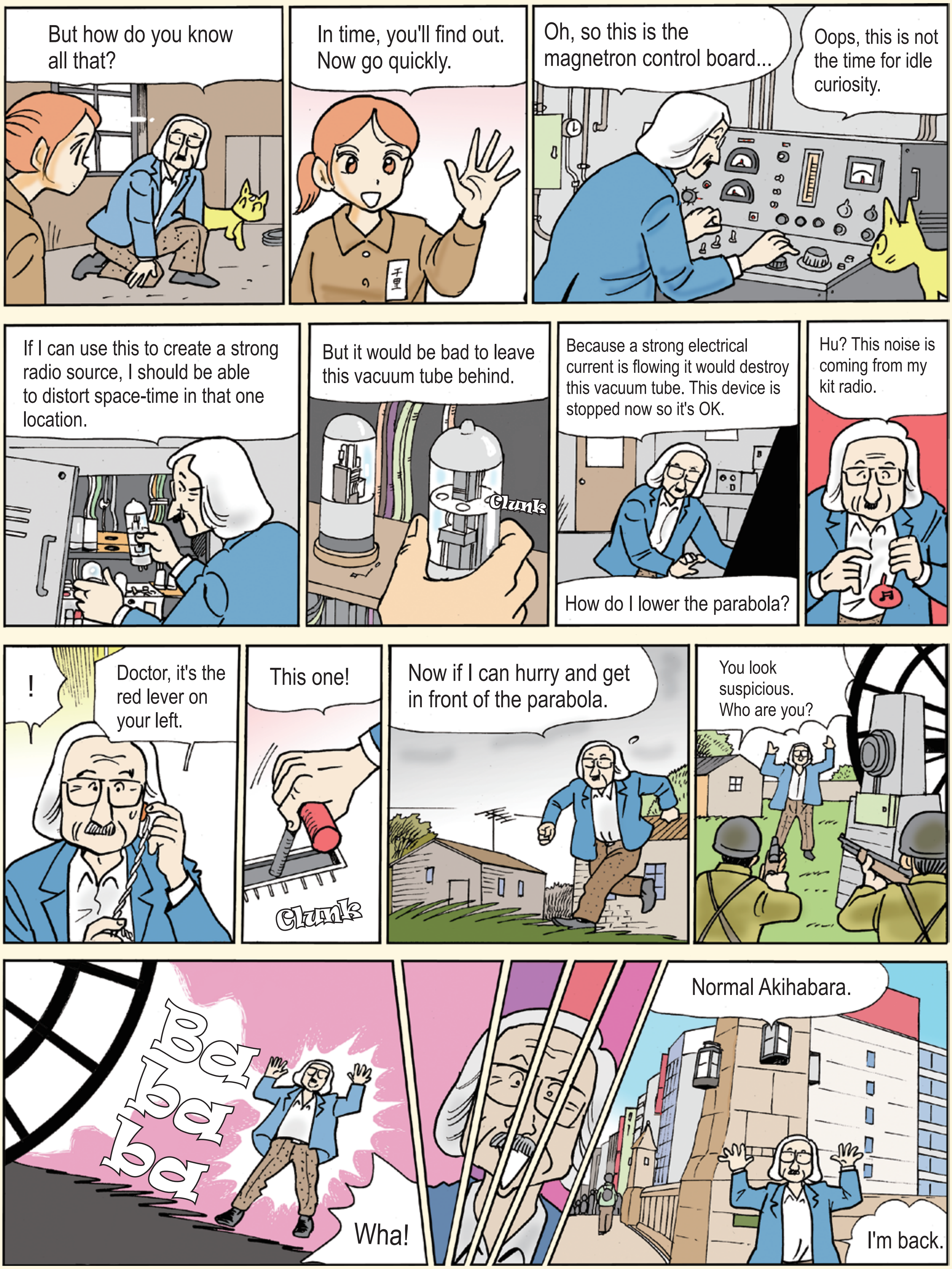
02 Near the entrance, guests encounter a 1.2 m aperture radio telescope manufactured by Sojiro Norizuki. Because a new telescope was produced in Nobeyama in 1992, this telescope was relocated from Toyokawa for the opening of Discovery Park Yaizu in 1997.

03 Inside, some of the tools cherished by Norizuki are on display, including tools thought to have been made by Norizuki himself, showing that he was an innovator. The exhibit is a must see for anyone interested in making telescopes.

04 Dr. Ishiguro looking through the 80 cm diameter equatorial mount reflector telescope made by Sojiro Norizuki. It is an unusual design sporting 3 eye pieces: Newton, Cassegrain, and Nasmyth. It has a large equatorial type fork mount, but it tracks celestial bodies using a special method known as friction drive that does not use gears.

05 (Left and Center) The GEMINISTAR III YAIZU optical-mechanical and digital full dome projection hybrid system installed in the planetarium provides inspiring visions of the Universe. Ayumi Matsunaga is in the podium. For this news investigation, I received great help from Matsunaga, and long term resident, for driving directions and such. (Right) After the Shimada investigation was over, I had a chance to drop by Discovery Park Yaizu. Front row from left to right: Ayumi Matsunaga and Mikiko Hirahama. Back row from left to right: manga artist Ryuji Fujii, Dr. Ishiguro, Head Curator Koji Konagaya, and Toshinori Ishigami.

Chapter 7-3: A Close Brush with Danger and a Safe Return to Akihabara 2017



Experiment 05

Let's Learn about the Structure of a Radio Receiver by Building a Germanium Diode Radio

The germanium diode radio kit Dr. Ishiguro purchased in Tokyo Akihabara Electric Town in the comic is a useful device for understanding the workings of a radio receiver. They are easy to order on the internet, so let's try actually building one and listening to a radio broadcast.

This issue's project is led by Ryuji Fujii, the artist who draws the comics part of ALMAr's Adventure. Here he is brandishing his personal legendary sword "soldering iron."

A Radio is a Device for Converting Radio Waves to Sound

Previously, we showed you an experiment where an electric current flowing around a circuit produced radio waves (ALMAr's Adventure 05, Experiment 04 “Let’s Try Making Radio Waves!”). That time, we used an AM radio to confirm that radio waves had been generated. Radio waves can't be seen with the eye, but an AM radio converted the generated radio waves into sound.

Now, this time, let's learn about a radio (receiver), which can pick up radio waves. There are many types of radios, but let's learn the structure by actually building a germanium diode radio with a simple structure. Lately it is possible to obtain a variety of radio kits through the internet.

By the way, within radios there are many different types, like shortwave radio, FM radio, and AM radio, based on the wavelength or the method of converting sound into radio waves. In order to broadcast sound on radio waves from an antenna, first the audio information must be converted into an electronic signal. This is called modulation. The AM and FM methods of broadcasting refer to this modulation. AM stands for Amplitude Modulation. Simply put, the volume of the audio is transmitted by the strength of the radio waves. FM stands for Frequency Modulation. In this case, the volume of the audio is transmitted as changes in the frequencies of the radio waves.

Even Without Batteries, You Can Hear Radio Broadcasts

A germanium diode radio is a type of AM radio. The structure is simple. In addition to a small germanium diode, the heart of the radio, all you need is an antenna, a coil, a variable capacitor, and an earphone. An electric power source, like a battery, is not needed. Actually the radio waves themselves provide the electric power. When the radio waves strike the antenna, an electric current flows. The germanium diode converts that current into audio.

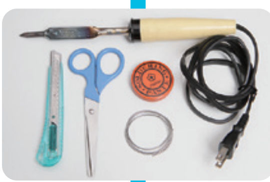
We said that the structure is simple. You can think of the assembly in 4 parts. First, the antenna which receives the radio waves. Then, the coil and the variable capacitor serve as the tuning circuit. You can turn the

Kit

An inexpensive germanium diode radio kit ordered online. It includes a polyurethane copper wire to make the coil antenna, a variable capacitor, a germanium diode, and an earphone.

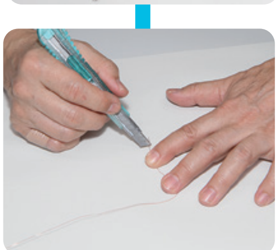
Pipe

You'll make the coil antenna by wrapping the copper wire carefully around a paper tube approximately 4 cm in diameter. If the diameter is a little small, or if there is still plastic wrap on the tube, you should wrap an additional piece of paper around the tube before wrapping the wire.



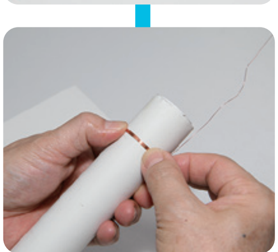
Tools

The tools used to make the radio this time are a utility knife, scissors, and a soldering iron, as well as solder and solder paste.



Preparing the Copper Wire

First, you'll make the coil. Scrape both ends of the polyurethane copper wire with a utility knife, exposing the copper core inside. To avoid twisting the copper wire, it is best to run it through a cylinder of some sort. Apply preliminary solder to the copper wire.

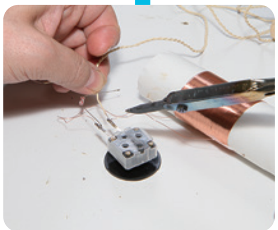


Making the Coil

Wrap the copper wire around the paper tube. Take care that the wire does not overlap or twist. You need to calculate how long of a wire to use based on the thickness of the tube. For this kit, 12 to 13 meters of polyurethane copper wire are wrapped around a 4 cm diameter tube without leaving any gaps.

Attaching the Dial

Attach the frequency tuning dial and its register to the variable capacitor variable capacitor to match the frequency of a particular broadcasting station and select those radio waves only. The germanium diode's role is to pull the audio electronic signal out of the radio waves. This is referred to as the detector. In AM, the audio signal is encoded into the signal strength of radio waves with frequencies higher than the sound waves and transmitted. So by simply converting the (low frequency) variations in the radio signal strength into electrical current, the audio signal can be recovered. Finally is the earphone which produces the sound. Unfortunately because this radio uses only the weak power produced by radio waves, you can't use it to produce a loud sound from speakers. For the earphone, you should use a crystal earphone which can produce sound even from a weak electrical current.



Soldering

Solder the copper coil, variable capacitor, diode, and earphone together as shown in the schematic.

Finished!

Well done.
"Can you hear anything Doctor?"

On that note, here is a Germanium Diode Radio Created by Dr. BS

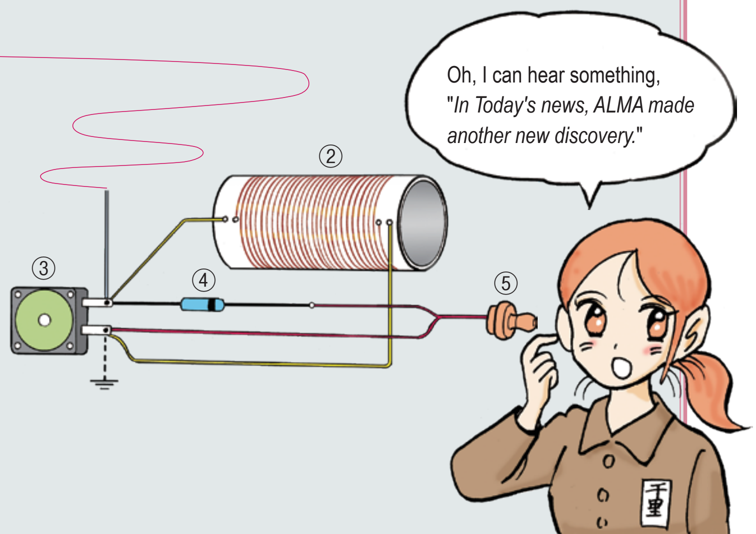
We had Dr. Ishiguro actually put together a kit radio for us. For the coil coupler he used a 46 mm outer-diameter plastic cylinder. Actually this was an empty powdered cheese container. He punched a hole in the bottom of the container and inserted a variable capacitor so that the dial for tuning the radio was on the outside of the container. The antenna and earphone are attached using alligator clips so that they can easily be removed and stored inside the container when not in use. Using a 5 m copper wire for the antenna, you can listen to AM broadcasts.

Together the coil and the variable capacitor form a tuning circuit, a device for selecting a specific frequency out of all of the radio signals coming from the antenna. The optimum number of coil turns will depend on the thickness and length of the wire, the diameter of the tube, etc.

①

In closing, let's look at a Germanium Diode Radio Schematic

A germanium diode radio is the simplest radio, consisting of just an antenna (①), a coil (②), a variable capacitor (③), a germanium diode (④), and an earphone (⑤). Unfortunately it can't produce loud sound, but you can try to improve the performance gradually by changing the shape of the antenna, or the type of diode, etc. It is a good radio to understand the principles of radio waves and receivers. You can investigate the designs and roles of the various components on your own.



Radios and Radio Telescopes are Cousins

A radio is a tool for detecting radio waves from manmade broadcasts. A radio telescope is a tool for detecting radio waves from celestial objects. Compared to a kit-built germanium diode radio, a radio telescope is a much larger and more complicated device; but the basic principles introduced on page 14 remain the same. The four steps are ① collect the radio waves with an antenna, ② select the frequency with a tuning circuit, ③ extract the signal with a detector, ④ and interpret the signal as sounds or images with an output device. Let's make a table comparing a radio and a radio telescope.

	Germanium Diode Radio	(Nobeyama 45-m) Radio Telescope
Antenna	copper wire	parabolic antenna
Tuning Circuit	coil and variable capacitor	waveguide or resonance cavity
Detector	germanium diode	mixer + detector
Output	earphone (sound)	computer (graph or image)

In modern parabolic antenna radio telescopes, the radio waves collected by the antenna are fed into a waveguide or resonance cavity. These have the same role as a tuning circuit, like the coil and variable capacitor in a radio. In addition, high frequency radio waves pass through a frequency mixer to down-convert to low frequency before going to the detector. We can say this corresponds to the germanium diode. In this way, radio waves are converted to an electric signal. Then we can measure the strength or take the spectrum. When cosmic radio waves were first discovered, they were observed by reading the output with an analog volt meter or listening to the sound with headphones. Now, almost all of the signals are digitalized and then processed and analyzed by computers.

★ If you remember that your handmade radio and large radio telescopes function on the same principles, you can feel a special connection to radio astronomy.

"ALMAr's Adventure" Production Unit

Illustration: Ryuji Fujii
Story: Akira Kawamura (Hoshinotechosha "Starbook Company")
Supervision: Masaaki Hiramatsu (NAOJ Chile Observatory)
Editor in Chief: Hiroyuki Takata
Design: Maki Kubo
Collaborators & Special Guests: Ayumi Matsunaga (Discovery Park Yaizu)/Ryuichi Sakamaki (City of Shimada Board of Education Continuing Education Division, Department of Education)/ Michito Shinogaya (City of Shimada Board of Education Cultural Properties Section of the Culture Group)/Taro Asahina (Shimada City Museum's chief curator)/Mikiko Hirahama (Discovery Park Yaizu)
News Collection Assistance: audio shop: SOUND BASE (Tokyo Radio Department Store Shops 3F)/vacuum tube shop: Kyodo Vacuum Tube Shop (Tokyo Radio Department Store Shops 2F)
Reference Literature: Yutaka Kawamura (Shimada Laboratory Research Project: What Wartime Mobilization of Science Brought About)
Translation: Ramsey Lundock

ALMAr's Adventure Issue 07
Publication date: June 1, 2017
Published by: NAOJ, Public Relations Center, Publications Office
Production assistance: NAOJ Chile Observatory, Nobeyama Radio Observatory

Back issues of ALMAr's Adventure can be viewed at
https://www.nao.ac.jp/en/about-naoj/reports/naoj-news/almar/

Nobeyama Radio Observatory, Nobeyama 45-m Radio Telescope