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Historical Sketch of the Scientific Field Survey in Hiroshima Several Days after the Atomic Bombing

Sakae SHIMIZU*

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In the morning of the 6th August, 1945 an atomic bomb was dropped upon Hiroshima. The whole city was destroyed instantaneously by the nuclear explosion of the bomb. The huge nuclear energy produced by chain reaction of fission of ^{235}U appeared first as a weapon in our human history. Immediately after the disaster survey teams of experimental nuclear physicists and pathologists were organized by Professor B. Arakatsu and rushed to Hiroshima. By our field survey the nature of the bombing and terrible aspects of the tremendous damage were first disclosed. In this paper is presented a short historical sketch of the first scientific field survey in Hiroshima performed by our teams.

KEY WORDS: Hiroshima atomic bomb/ Field survey/ Induced radioactivity measured/

I. PROLOGUE

Early in January 1939 an announcement of discovery of nuclear fission of uranium and thorium by Hahn and Strassmann gave all physicists and chemists concerned with studies of atomic nuclei a great shock and excited them immediately to develop impetuous researches on this particular nuclear phenomenon. In Kyoto, immediately upon hearing this amazing news Professor B. Arakatsu and his group started studies on some aspects of the fission process. Only ten months later, from his laboratory was published a report on the experimental determinaton of number of fission neutrons per fission by thermal neutrons, $\nu = 2.6$.[1] Then he and his coworkers proceeded to study photofission of uranium and thorium by irradiation of Li(p, γ) 17-MeV and F(p, γ) 6.3-MeV gamma rays produced by the use of a 800-kV Cockcroft-Walton machine. Results of their pioneering works were obtained in the fall of 1940, one and half years before Japanese participation in World War II on the 8th December, 1941.[2,3] This study was followed by that on photonuclear reactions of some nuclei at the early stage and even during the war.[4]

Due to outbreak of the war two active members of our group, Drs. Y. Uemura and M. Sonoda, were forced to leave the laboratory, because they were mobilized to the military service. During the war period in the laboratory of experimental nuclear physics headed by Professor Arakatsu, only two of his staffs, Assistant Professor K. Kimura and Lecturer S. Shimizu, and a few graduate students, and several undergraduate students temporarily could study with us, were engaging in some experimental works, *i.e.*, construcion of a cyclotron with a magnet of 100-cm diameter,[5] photonuclear reactions,[6,7]

* 清水 榮: Professor Emeritus, Institute for Chemical Research, Kyoto University, Kyoto, Japan

measurements of fission and absorption, and capture cross-sections of natural uranium for thermal neutrons.[8,9] In the later half of the war period a research committee organized by Professor Arakatsu by a support of our Navy. The committee was consisted from some professors of Kyoto University, including Professors H. Yukawa, S. Okada, S. Sasaki, M. Kobayashi, and we of two, Kimura and Shimizu of Professor Arakatsu's laboratory, and Professor E. Kanda of Tohoku University, and Professor T. Okuda of Osaka University. Almost of them could not develop their planned works owing to the difficult war-time confusion and very meager budget and materials. Professor Okada, however, studied metallurgy of uranium and succeeded in getting metallic powder of pure uranium from uranium oxide,[10] and Professor Kobayashi attempted to calculate possibility of chain reaction of uranium fission by using some experimental data available at that time.[11] In the final stage of the war, separation of ^{235}U by applying the centrifugal method was studied and only a few months before the end of the war a basic design of a high-speed rotating apparatus of magnetic suspension and magnetic driving for this purpose was completed. But, it was never fabricated owing to destruction of nearly all industry by the air raids. Our cyclotron, not completed by the end of the war, was smashed away by the Occupation Forces by mistake on the 23th November, 1945.

These wartime works concerned with uranium under the supervision of Professor Arakatsu in Kyoto were aimed at confirming the possibility of a chain reaction of uranium fission, of which realization could result into the nuclear bomb by the Allied Powers. Before the last day of the war, the 15th August, 1945, however, we had carried out no promising experimental project to get a positive clue for this possibility. Here, it is noted that during the whole period of the war we of Japanese scientists did not get any information on large activities of Allied Nations, the Manhattan Project, excepting a news in 1943 that a British military unit destroyed thoroughly the Norsk Hydro plant in Norway in 1943 where production of heavy water was being conducted on a large scale by German Forces. The forgettable day of disaster for all Japanese came on the 6th August, 1945, especially for my friend T. Yanabu the most momentous day of his whole life.

II. THE FIRST FIELD SURVEY

In the afternoon of August 6th, 1945, we received an astonishing information that in this morning (8:15 a.m.) Hiroshima was destroyed thoroughly by only one particular bomb dropped upon its center. When we heard this news we could not believe that it might be so-called atomic bomb, because we knew well that the fission chain reaction of uranium cannot be realized unless considerable amount of highly enriched ^{235}U can be separated and such a very difficult project necessitates unimaginably large-scale cooperative works of a great number of leading scientists, engineers, military personnel, and labourers under a supreme commanding organization with a high-minded leader. But, we were trembled with fear for the last weapon had just come to us. Professor Arakatsu organized at once an exploring party in order to disclose the nature of this terrible bombing by observing the real state of the disaster in Hiroshima and measure tremendous radioactivity, if it was produced; our party headed by him consisted of ten members,

Fig. 1. Destroyed central area, about 800 m from the hypocenter. A building far away on the right-hand side is Hiroshima Prefectural Commercial Exhibition Hall, 160 m northwest from the hypocenter. This building is preserved now still in ruins and called Atomic Bomb Dome as a witness to the horror of the atomic bombing and also as an appeal to the human sanity for world peace.

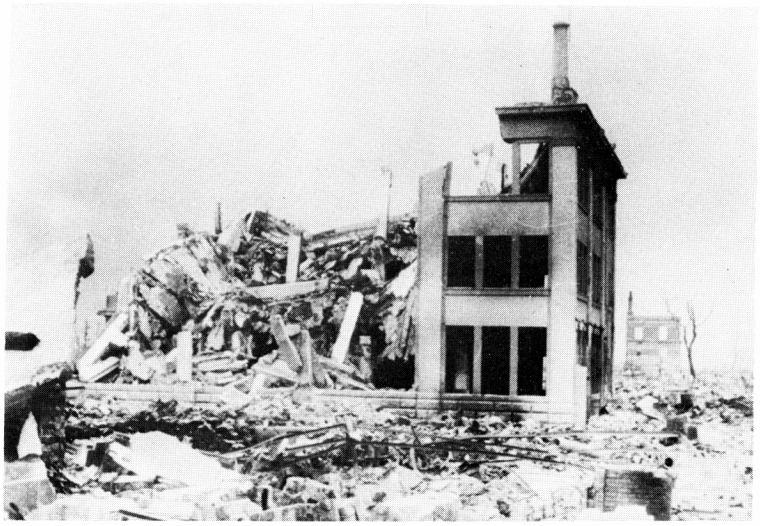

Fig. 2. Hiroshima Gas Company building, 250 m south from the hypocenter.

Fig. 3. At a place probably about 850 m from the hypocenter. A tall building in the center is Fukuya Department Store, 800 m east from the hypocenter.

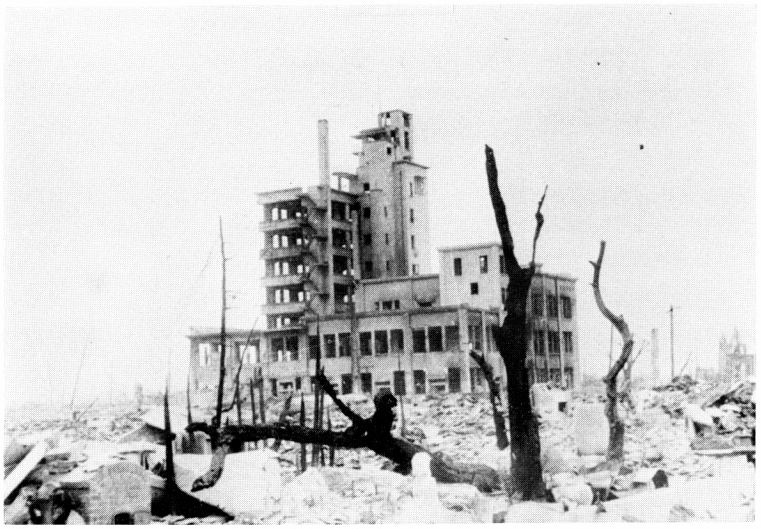

Fig. 4. Chugoku Shimbun-Sha (newspaper company), 900 m east from the hypocenter.

i.e., four experimental nuclear physicists (Professor B. Arakatsu, Assistant Professor K. Kimura, Lecturer S. Shimizu, and graduate student T. Hanatani), three pathologists of our Medical School (Professor S. Sugiyama, Drs. M. Shimamoto and M. Kimura), a Navy Technical Lieutnant (R. Ueda) a Navy Engineer (S. Ishida), and an Army Technical First Lieutenant (Ikeno).

Our party left the Kyoto Central Station for Hiroshima at 21:30 p. m. on the 9th August, three days after the bombing. At the station we heard a news that U.S.S.R. suddenly participated in the war and Russian troops entered into Manchuria and Japanese Southern Sakhalin in the morning of the preceding day. Arriving at Hiroshima at noon of the 10th, at the first glance we were shocked marvelously. The whole city was destroyed completely and remained in ruins with a special smell of death and with few collapsed ferroconcrete buildings standing ghostlike (see Figs. 1-4). Green leaves of all pine trees on the hill some one km to the north of the central station were changed to dark brown. Few people entered into the city for the victims' rescue were wandering on the street. Even near the central station we witnessed killed bodies still not evacuated.

We first visited the Headquarters of the Second General Army lodging in tents temporarily installed at the East Parade Ground in order to get a summarized report of the disaster as well as to ask for a guide in the damaged city. We were requested to participate in a conference urgently held in a building of the Hiroshima Army Base of Supplies, with attendance of Dr. Y. Nishina of Institute of Physical and Chemical Research in Tokyo, who rushed to there from Tokyo in the afternoon of the 8th, surviving local military staffs, Army and Navy higher staff officers from the General Supreme Headquarters in Tokyo, and technical and hospital staffs from the Kure Naval Station, and science teachers of the Naval Academy at Edajima Island in Hiroshima Bay. On this conference the attendants exchanged information on various aspects of the bombing and discussed how to protect or minimize terrible effects of such a bombing. A serious discussion was focussed on the nature of this novel bomb, and further investigation was strongly hoped. All of us were thrown into despair by a new information that a similar bomb was also dropped on Nagasaki in the morning of the day before.

After the conference we went around in the central area of the city escorted by an Army officer to observe features of damage, almost houses were broken down and burned away, only big collappsed ferroconcrete buildings were standing in the field of burned rubbish, damaged streetcars were thrown out several meters from the track, and stone parapets of some bridges were toppled down sideward. These states of destruction suggested tremendous strength of the explosion blast. During our tour of inspection through destroyed areas we collected sands and soils from the surface of the ground not trodden, especially gathered carefully the surface soil on the potato field in the corner of the West Parade Ground, as this area was considered to be situated near to the hypocenter.

When we were walking around in the destroyed downtown, we were very anxious for safety of our friends T. Yanabu and his wife, since at that time he was a young Navy Technical Lieutenant serving to supervise munition works in Hiroshima district and their lodging house was located near the east foot of Yorozuyo Bridge about 980 m from the hypocenter. But, we could not hear anything of their fate after the bombing.

After we walked around in the damaged city for several hours, we determined to go back to Kyoto by a convenient train we can get as soon as possible, because there was a rumour that our Kyoto might be attacked by a similar bomb within coming few days. We left Hiroshima by a train at about 23:00 p.m. and arrived home town at 11:30 a.m. near noon of the 11th.

On the 10th Professor Sugiyama and his two assistants went directly to Ninoshima Island in Hiroshima Bay where many victims were received in the quarantine buildings. They were the first pathologists who could examine in detail victims killed by the direct effects of the atomic bomb.

Immediately after we came back to the laboratory in the afternoon we started to measure beta activity of the samples collected in Hiroshima in the preceding day using a duralumin G-M tube of 12-mm diameter, 0.1-mm wall thickness, 4-cm effective length, and filled with air of 9.0 cm Hg plus ethyl-alcohol vapor of 1.5 cm Hg. The natural background of this counter was about 18 cpm. The sand and soil samples were spread uniformly in a paper boat of 3 cm×2 cm placed 4 mm beneath the counter tube. At that time in our laboratory, such thin-wall G-M counters were being used for detection of induced beta activity by the photonuclear reaction (γ, n) with copper and some other elements. Within few hours we found induced beta activity in some materials, especially the soil samples we got from the surface of the West Parade Ground located within several hundred meters from the hypocenter showed considerably strong activity, 70-80 cpm, while soil samples gathered at the East Parade Ground 2.5 km apart from the hypocenter showed no appreciable activity. The maximum energy of the observed beta rays was estimated approximately to be 0.9 MeV by its absorption in aluminum. After an elapse of 12 h we measured again the activity and its half-life was estimated roughly to be 10-14 h. No acceptable alpha activity was detected and activity due to any fission product could not be identified, which might have fallen down on the ground. In these measurements we worked in cooperation with our students, H. Matsui, T. Hayashi, and Y. Ishizaki. Under these circumstances Professor Arakatsu determined to send the second exploring party to collect as many samples of various kinds as possible by the exhaustive survey in the whole area of Hiroshima in order to confirm the nuclear explosion of the bomb.

III. THE SECOND FIELD SURVEY

The second exploring party started from Kyoto at night of the 12th August. The party directed by myself was consisted of nine members; two Navy Technical Lieutenants (R. Ueda and R. Ishiwari), one graduate student (I. Takagi), four undergraduate students of physics (S. Kondo, H. Takase, K. Aoki and Y. Ishizaki), and one Navy Assistant Engineer (E. Hondo). In the following morning the present author and Ueda first visited the Kure Naval Station on a special mission with a letter of Professor Arakatsu, while the rest of the party went directly to Hiroshima led by Ishiwari. In Kure Naval Station we saw Naval Surgeon Vice Admiral Dr. N. Fukui (Director, Kure Naval Hospital) and his staff and then Navy Technical Captain Dr. M. Mitsui of the Kure Naval Arsenal to inform them that our finding of strong induced radioactivity of the specimens from Hiroshima

confirmed our opinion that explosion of the bomb might be caused by nuclear reaction. I handed over a letter of Professor Arakatsu to Dr. Mitsui. At about 15:00 p. m. we of two could join the group of other members in the ruined center of Hiroshima. It was expected that if the bomb was a uranium bomb a great number of neutrons as well as tremendous nuclear and heat radiation might have emitted from the center of explosion (epicenter) and the substances on the ground might be induced to be radioactive by intense neutron irradiation. Moreover, it was also expected in some areas under the mushroom-shaped cloud there could be found various fission products. We walked through the streets scattered with rubbish and in ruins of the disaster to collect various samples which seemed to be radioactive till the evening of the 13th and all the day on the 14th. We do remember that when we were walking around the center of the city we witnessed a horrible scene of killed bodies being piled up behind a big collapsed building. In these two days we could collect several hundred samples including

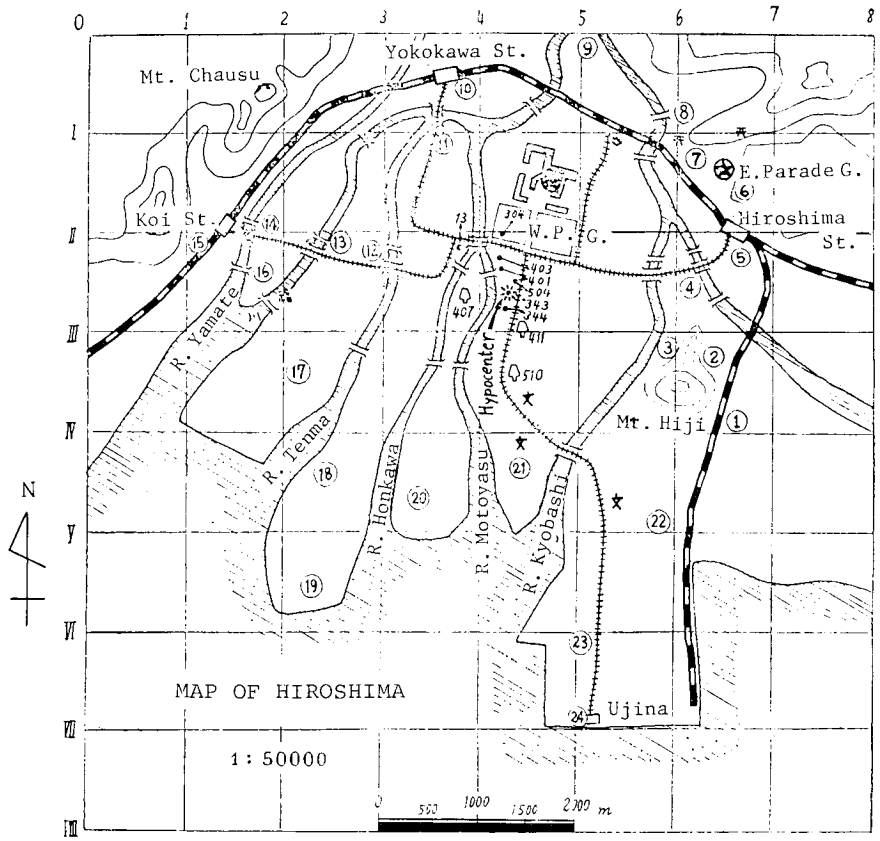

Fig. 5. Rough map prepared at the time of our survey. There are shown places where some samples were collected on the 10th, 13th, and 14th August, 1945. The hypocenter was marked as southeast of the Motoyasu Bridge. This was not the point we presumed and probably was a drafting error, since our estimated point, about 300 m south of Gokoku Shrine, was located north of the bridge. Refer to Ref. (13).

pieces of a broken Watt-meter, bones of killed horse, porcelain insulators containing sulpher and others, of which induced activity was assigned easily to that due to (n, γ) or (n, p) reaction. In the afternoon of the 13th we happened to meet Navy Technical Lieutenat Commander H. Tamura on the street near a damaged building of Fukuya Department Store. He was a senior of Yanabu and had their office in this building. We heard from him that our friend Yanabu and his wife met the nuclear bomb disaster in their lodging house at 8-chome, Ōtemachi, located about 900 m to the south of the hypocenter, however, they were both wounded fortunately not so seriously and could escape from the city and went to their native place, about 90 km from Hiroshima. We all felt relieved by this information.

In the evening of the 14th we left Hiroshima and hurried back to the laboratory in Kyoto with rucksacks filled with collected samples.[12] Immediately after came back to the laboratory, at about 14:00 p.m. of the 15th, investigation of activity of many collected specimens was started with concerted efforts of all members. At noon of this day our Emperor declared the unconditional surrender of Japan; the war came to an end. Until the evening of the 16th activity of collected samples had been measured. A rough map of the city was prepared, in which some points where important samples were collected, as shown in Fig. 5.

IV. MEASUREMENTS OF BETA ACTIVITY OF COLLECTED SAMPLES

In Table I are given some results of our measurement in that time; with some samples measured intensity of the beta activity, the estimated maximum energies, and half-lives are shown. Among the objects examined a horse-shoe magnet of an integrating Watt-meter buried in a collapsed house near the hypocenter was found to be especially interesting. It carried intense beta activity showing 374 cpm. Even though its surface was planed off to a depth of about 1 mm by a grinder the magnet showed still the same activity. This fact told us that the observed beta activity was due by no means to any scattered radioactive substance but induced by neutron irradiation. It was also the cases with many other specimens collected near the presumed hypocenter.

Another specially remarkable case was a bone of a horse which killed on the road at the time of explosion. It showed an extraordinary strong activity of 637 cpm per gram of the specimen. By the chemical analysis of the active substance it was found to be attributed mainly to the activity of phosphorus and somewhat weaker activity of calcium. The half-life of the activity of the precipitated phosphorous was measured to be about 18 days. This is evidently to be identified as ^{32}P produced by the well known reaction by slow neutrons, $^{31}P(n, \gamma)^{32}P \rightarrow {}^{32}S + \beta^-$ of a half-life of 14.3 days. It was, however, not evident whether neutrons with fairly low energies themselves fell directly upon there or fast neutrons arrived at and then were slowed down inside the animal tissue.

It is here noted that the sand collected 1 m below the surface at the West Parade Ground showed activity 50 cpm smaller that on the surface. Moreover, it is interesting that the observed activities of our collected samples were in most cases due to fast neutrons, since the activities induced by slow neutrons in the elements we examined are, in general, rather short (except phosphorus) and decayed to very low intensities not observed

Table I. Measured β activity from 6 p.m. Aug. 15th to 6 p.m. Aug. 16th, 1945.

Type of Sample	Identification number of sample	Element	β activity (cpm)	Half-life Measured	Half-life Known	Measured maximum energy (MeV)	Location of sample, distance from hypocenter (m)	Quantity of measured sample (g)
Bone of horse	0	p	529	18 d	14 d (^{32}P)	1.5	0	0.83
Sulpher sticked to porcelain insulator	407	S	35	13 d	14 d (^{32}P)		250	1.5
ditto	411	S	33	13 d	14 d	1.4	350	2.2
ditto	510	S	23				800	2.6
Gum tire	13	S	16				700	1.3
Iron plate	343	Fe	85			1.5	0	1.9
Iron magnet	401	Fe	374	15 d	2.6 h (^{56}Mn)		500	
Iron brock	304	Fe	58				700	21.2
Lime	344	Ca	20	27 h and 16 d	12.4 h (^{42}K) 8.5 d (^{41}Ca)	1.2	400	1.6
ditto	404	Ca	7				300	1.5
Cement	504	Ca	14	22 h and 19 h	ditto	1.5	500	1.8
Aluminum plate	401	Al	21	15.5 h	15 h (^{24}Na)		500	3.0
Solder	401	Sn & Pb	364	2.8 d		2.2	500	0.46

distinctly by our apparatus after an elapse of several days. We could only say, at least, that a part of emitted neutrons from the exploding bomb had very high energy and very great penetrating power. By examining substances containing sulpher we found also ^{32}P produced by $^{32}S(n, p)^{32}P$ reaction, of which half-life was estimated about 13 days in agreement with the reported value. Many specimens of iron pieces showed activities with much longer lives. In that time we could not assigned those to hitherto known reactions by neutrons for any other contaminated elements. The soldering material used at the joint of the rotating plate and its axis of the Watt-meter showed an intense activity, of which half-life was measured to be about 2.8 days. The material was found, by spectrum analysis, to be an alloy of lead and tin. Based on these observations of vairous induced activities it was inferred that when the bomb explodes a tremendous number of neutrons with very wide range in energies are emitted and, of course, terrible heat and strong shock waves spread from center of explosion.

It was also expected that very strong radioactive fallout, *i.e.*, fission products, would be found in some areas in the city. In order to find such fission products fell upon the

Table II. Measured β activity outside the downtown on Aug. 15th and 16th, 1945.

No.	Places where samples were gathered	Direction & distance from the hypocenter		Intensity of β activity (cpm)
1	In Army Base of Supplies	S.E. about 2.5 km		no
2	The east foot of Mt. Hiji	S.E.	2.5	no
3	Its west foot, in the shrine	E.	2.0	no
4	The west side of Kōjinbashi Bridge	E.N.E.	2.5	weak 11, 13
5	The east side of Hiroshima Station	N.E.	2.5	no
6	The East Parade Ground	N.E.	2.5	no
7	In the Samezu Shrine	N.E.	2.0	no
8	Higashi Nakamachi	N.N.E.	2.0	no
9	Near the back gate of the 5th Engineer Corp	N.	2.5	weak 8, 10
10	The east side of Yokokawa Station	N.N.W.	2.5	weak 8, 10
11	The south side of Yokokawa Bridge	N.N.W.	2.5	no
12	The west side of Tenma Bridge	W.	1.5	no
13	The east side of Fukushima Bridge	W.	2.5	weak 12, 14
14	The east side of Koi Bridge	W.	3.0	no
15	About 300 m southnorthwards Koi Station	W.	3.5	no
16	The east side of Asahi Bridge	W.	3.5	intense 106
17	Near the Minami Kannon-cho Post Office	S.S.W.	2.5	no
18	Funairikawaguchi-cho	S.S.W.	2.2	no
19	The shooting field	S.S.W.	3.0	no
20	The Yoshijima Airport (pieces of destructed airplane and sand)	S.S.E.	2.5	no
21	HgI_2 & S in the chem. lab. in Hiroshima Tech. Coll.	S.	2.0	no
22	$AgNO_3$ in the chem. lab. in Hiroshima High School	S.S.E.	2.0	no
23	9-chome, Ujina	S.S.E.	4.0	no
24	4-chome, Ujina	S.S.E.	4.5	no

ground, in the morning of the 14th, by a car which was offered to our use by courtesy of a staff officer of the Second General Army, three members (Shimizu, Ueda, and Ishizaki) could go around in the peripheral areas of the city, and at some fifty different places, they collected many specimens, sands, soils, chemicals, debris of concrete blocks, roof-tiles and others, and observed the states of damage mainly by the very strong blast. Measured beta activity of specimens collected in this survey tour are listed in Table II. It must be noted that although many of the collected samples showed no detectable activity, some of them, especially a soil sample collected near the east foot of Asahi Bridge located about 3.5 km west of the hypocenter showed fairly strong activity. The strong residual radioactivities found on the ground in the western and northern areas were due to the fission products fell down with a heavy shower of black big drops which attacked these areas between 9:00 a.m. and 16:00 p.m. of the 6th, several hours after the explosion of the nuclear bomb. At that time we could not perform the radiochemical analysis of the fallout. More than twenty years later, from these area some long-life fission products were identified.

The primary object of our exploring teams was to investigate effects and the nature of a completely novel explosion; we had to disclose whether there was only one bomb or more, whether it exploded on the ground or in the air, whether it was actually nuclear bomb or simply a very large high-explosive bomb which incidentally scattered radioactive material, how large effects were caused by the blast, heat, and neutron or gamma radiations, and many similar questions on the bombing. In addition, we had to obtain any clue about means by which we can protect ourselves against terrible effects of such a bombing as much as possible. Under these circumstances immediately after the bombing our observation was rough and accuracy of measurements of activities of the collected samples performed in only few days was rather poor. But, it was very significant to estimate the explosion point (epicenter) of the bomb as well as the approximate number of neutrons reached upon the ground. From the observed blast effects and thermal shadows still remaining on surface of concrete and granite, the epicenter was presumed 500-600 m above a place about 300 m south of Gokoku Shrine.[13] Among the samples collected shown in Table I sulpher sticked in porcelain insulators of the electric poles were believed to meet comparatively simple geometric conditions. The relationship between location of samples and measured beta rays from ^{32}P caused by $^{32}S(n, p)^{32}P$ reaction is shown in Table III. This result suggested us that the epicenter was simultaneously the center of production of fast neutrons. Based on the measured activity of ^{32}P induced by slow neutrons in a bone of a killed horse located near the hypocenter,

Table III. Dependnce of observed relative β activity of sulpher on distance from the presumed hypocenter.

Distance from presumed hypocenter (m)	Relative observed β activity
250	35
350	23
800	13

although at that time the slowing down of the neutrons in the living tissue and in air was not precisely known, we could estimate number of the fast neutrons reached upon the surface of the ground near the hypocenter to be $10^{13}-10^{14}$ per cm^2.

From these mesurement data and our observation of the actual states of the damaged city, eight days after the disaster we had reached a conclusion that the Hiroshima Bomb should be a bomb utilizing the uranium fission and its power was equivalent to explosion of TNT of about 2×10^4 tons. In the morning of the 9th a similar bomb was dropped on Nagasaki. On the 15th August Japan surrendered unconditioally and the war came to an end. Due to physical fatigue and may be to an effect of exposure to nuclear radiations during the field survey in Hiroshima, in the night of the 19th I spat out much bloody sputa, and I was forced to lie on a bed for about three months. The results of our survey and investigation were reported first by Professor Arakatsu on Press Asahi (Osaka) one month later, September 14-17th, 1945, and a formal report was published in 1953.[14]

V. TRAGEDY OF THE THIRD FIELD SURVEY PARTY

From the last week of August, from our Kyoto University several teams were sent to Hirshima in succession. They were more than 80 workers in various fields of fundamental and clinical medicine, including several nurses, with objects to establish rescue centers for the injured still in very cruel circumstances as well as to develop the wide-range studies on very particular diseases and injuries caused by explosion of the nuclear bomb. The third exploring party of our laboratory went to Hiroshima on the 15th September. The leader of the team was Assistant Professor K. Kimura and other members were J. Hori (Assistant of Physics), T. Hanatani (graduate student), K. Nishikawa and S. Takai (undergraduate students), and M. Murao (technician). They armed with some instruments and planned to stay in Hiroshima area for more than one week to observe decay of residual radioativity, of which data might be very valuable for resuscitation of the city, and to work in cooperation with our medical people. Only at the first stage of their invetigation, in the night of the 17th, their lodging house, Ōnoura Army Hospital, located about 32 km southwest of Hiroshima, was smashed away suddenly by a land-slip caused by a very big typhoon with heavy rain attacked this area. By this tragic accident three members of our team, Hori, Hanatani, and Murao, were killed instantly, and also were perished eight medical colleagues, Professors S. Mashimo and S. Sugiyama, Drs. T. Ōkubo, M. Shimamoto, M. Nishiyama, K. Shimatani, and undergraduate students K. Hirata and N. Hara. The measuring apparatuses and some important records were all swept away by the mud flow. The survey on the residual activity and physical effects was never made by our group since this tragedy. But, after this accident our medical workers, Professors T. Kikuchi, G. Wakisaka, S. Amano, and many others continued their investigation on so-called atomic bomb disease caused by irradiation of intense nuclea radiations for more than thirty years and achieved many invaluable results.

VI. AN ASPECT OF THE DISASTER

As to the number of deaths by the atomic bomb various data have so far been published, but the accurate figure is still not available today after 37 years. A reason for this fact is attributed to the almost complete destruction of the administrative agencies and official records and documents by the bombing. The accurate number of people in Hiroshima at the instant of the explosion is still unknown. However, at present it is estimated roughly to be 350, 000, including about 43, 000 military servicemen and about 50, 000 Koreans. Almost all of them were exposed directly to nuclear and thermal radiations or the blast from the nuclear explosion of the bomb. Of these total number of the exposed, about $140,000 \pm 10,000$ are estimated to have died by the end of 1945, about 20, 000 of them being military servicemen and about 20, 000 Koreans. In Nagasaki about 270, 000 people are estimated to have been exposed, of whom approximately $70,000 \pm 10,000$ probably died by the end of 1945. In Nagasaki about 2, 000 Koreans are estimated to have been died.

A great many books, reports, and papers on Hiroshima and Nagasaki bombings and its effects have so far been published. The collection of Japanese studies and surveys performed during several years after the disasters had been published in two huge volumes in March 1953.[14] An excellent summary of studies on various aspects of effects of the atomic bombings entitled "HIROSHIMA AND NAGASAKI— The Physical, Medical, and Social Effects of the Atomic Bombings" had been published in Tokyo, New York, and London on the 36th anniversary of Hiroshima disaster, the 6th August, 1981.[15]

VII. IN FEW MONTHS FOLLOWING THE END OF THE WAR

From the beginning of September 1945, several young members who graduated from our laboratory and mobilized to the military services, came back gradually to Kyoto to join again our group. Under instructions of our boss Professor Arakatsu, we first cleaned up the laboratories and worked hard to keep instruments and facilities in working condition in order to start again experiments of nuclear physics as pure scientific problems of our interest, although we had to live in very confused and severe circumstances after the war. Professor Arakatsu gave an interview to American reporters and cameramen in his office in the evening of the 17th October. His statement as a Japanese nuclear physicist expressed well an aspect of his high personality we all respected. It still remains as a memorial in their minds of his pupils who worked in his laboratory. He stated his views as:

Peace has been restored. Liberalism is growing now new in all of the districts of Japan. I am glad to have an opportunity of making here a speech upon atomic bomb and nuclear physics, because during the war I was conducting experiments in some of the uranium problems.

When I received the information that an atomic bomb was dropped upon Hiroshima, I could not believe it, at first. But, in a corner of my sense I said to myself. "Now, at last, the suspected matter has come from the properly expected land." So, I went straight to the destructed place and observed there the induced radioactivity of various substances laid down on the ground.

I could immediately ascertain the bomb was one of very atomic origin.

The disrupting power of the bomb is so enormous as human beings had never experienced and the nature of its effects upon mortals, so-called "atomic bomb disease", is beyond human endurance. But, a few number of these bombs have contributed in bringing the war to an end and saved numberless lives of two nations from the sacrifices which might have been inevitable if the war were further continued.

The theory utilizing atomic energy of uranium nuclei is a matter of widely known among the physicists in the world. But, the practical execution of atomic bomb is extremely uncertain and hazardous for most nations and especially for those lacking raw materials.

The first achievement of this work in America must be attributed not only to the abundance of material but rather principally to the capacity of embracing many great scientific brains and to the well-established system of research on a large scale.

If the American news is true, special stress must, also, be laid on the discovery of ingenious technique that pure graphite may be used as neutron slower-and-container and makes it possible to produce large quantity of trans-uranium element, Plutonium.

At any rate, the appearance of this new bomb suggests us that the entirely new period of science and technology is really coming on. The bomb made itself to be a key to open the door of new enlightened era. The key, however, should not more be used. The atomic energy is now expected to be used as a primary power of new alchemists in future.

Pure scientific discoveries in the domain of nuclear physics and their due applications to many branches of science will induce human beings not only to extend their superiority in external life but also to develop their internal conception upon nature profoundly. They may feel, then, themselves new dignity and new honour in that they are human beings.

In the morning of the 20th November in our laboratory room where the Cockcroft-Walton accelerator was in operarion and a room where a cyclotron was under construction were occupied by the Occupation Forces (about 20 soldiers directed by an officer), and we were forbidden to enter into these rooms. Three days later our cyclotron was smashed away, and, in addition, unfortunately some valuable records and data of our early studies on the Hiroshima disaster were confiscated by them and have never been recovered.

About the same time we could get a letter from Yanaubu informing that he and his wife were wounded, fortunately not so seriously, inside the lodging house located some 900 m apart from the hypocenter in an instant of explosion of the bomb and two days later thery could reach at last his native house in Jōge about 70 km northeast from Hiroshima and were confined to beds by illness. They suffered from characteristic symptoms of the atomic bomb disease. *i. e.*, loss of hair and lesions due to the blood disorder, especially several weeks after the disaster. They were, however, becoming gradually convalescent some two months later. About one year later they could recover almost their health so as to come back to Kyoto, and in June 1946 Yanabu could join again our group.

From April 1947 he started again some experiments, first in the field of solid state physics, as a research assistant. From summer of 1952 a big project of reconstruction of our cyclotron in our Institute for Chemical Research was commenced. We of about twelve young members, headed by Professor K. Kimura, worked very hard day and night to rebuild our accelerator, *i. e.*, fixed-frequency two-dee cyclotron with an 80-ton magnet of

105-cm pole-tip diameter, for three and half years in the rather difficult period after the war. On the 12th December 1955 we achieved first an external beam of 15-MeV deutrons. Yanabu devoted himself to this laborious project as one of the most active members. Since this time he has been working actively in the field of nuclear physics as a leader of our Cyclotron Laboratory.

VIII. EPILOGUE

I am now conjuring up visions of the horrible nuclear holocaust in Hiroshima 37 years ago. At the first General Assembly of the United Nations held at London in January 1946, all member nations passed unanimously a resolution on the international control of nuclear energy so as to use it not for military purposes but only for peaceful benefits to promote the human welfare. But, two different major plans were proposed from the U. S. A. and the U. S. S. R. as to ways and means of control, timing and sequence, and enforcement and sanctions. Since then until the present, the International Atomic Energy Agency (IAEA) was established in 1957, the Partial Test Ban Treaty came into effect in 1963, Nuclear Nonproliferation Treaty in 1970, and other agreements and resolutions have been adopted at the meetings of the United Nations, however, these have not yet been ratified in some member nations. Since the first nuclear explosion test at Alamogordo in New Mexico on the 16th July, 1945 up to now there have been about 1330 nuclear explosions, atmospheric and underground, including H-bombs. The test of the first H-bomb was performed at Eniwetok Atoll in the Central Pacific on the first November, 1952. At present, in addition to the tremendous nuclear bombs and missiles as the strategic system for determent of war, some kinds of nuclear weapons for the battlefield use, including so-called neutron bomb, are being in production. The political leaders of the present world believe that to secure East-West nuclear-arms balance or to secure superiority over the other side is the most real policy to ensure the peace of the world. We have, however, a fear of such a recent situation being apt to accelerate the nuclear-arms race, which would result into the catastrophe of mankind. It is quite evident that there is no winner in the nuclear war.

All of us are now standing at a crossroads where we must choose either nuclear disarmament or annihilation of our civilization and culture. Everbody all over the world should consider and reflect upon many aspects of the present nuclear problems in schools and churches, and also in homes in the most quiet mid-night to open a new era which could be achieved by the revolution in our minds and spirits by introducing a quite new philosophy on the meaning of life and nature, which, I hope, man can find in the profound Buddhism philosophy.

In connection with the happy circumstance that this paper will be published in the number of this "Bulletin" issued in memory of Professor Takuji Yanabu's retirement, it is a great pleasure for me as his friend of long standing, to express my most profound admiration for his contribution to the development of nuclear physics in our country as well as for his friendship of forty-two years.

REFERENCES

(1) T. Hagiwara, *Rev. Phys. Chem., Japan*, **13**, 145 (1939); *Memo. Coll. Sci., Kyoto Imp. Univ., A*, **31**, 19 (1940).
(2) B. Arakatsu, Y. Uemura, M. Sonoda, S. Shimizu, K. Kimura, and K. Muraoka, *Proc. Phys.-Math. Soc., Japan*, **23**, 440 (1941).
(3) C. Arakatsu, M. Sonoda, Y. Uemura, and S. Shimizu, *Proc. Phys.-Math. Soc., Japan.* **23**, 633 (1941).
(4) B. Arakatsu, M. Sonoda, Y. Uemura, S. Shimizu, and K. Kimura, *Proc. Phys.-Math. Soc., Japan*, **25**, 173 (1943).
(5) Professors B. Arakatsu and K. Kimura were mainly responsible for its construction as a project of Institute for Chemical Research of our university, and they were busily engaging in difficult negotiations with some governmental agencies and industrial companies to promote its construction as fast as possible.
(6) B. Arakatsu, S. Shimizu, T. Hanatani, and J. Muto, *J. Phys. Soc., Japan*, **1**, 24 (1946).
(7) S. Shimizu and J. Muto, *Memo. Coll. Sci., Univ. of Kyoto, A*, **25**, 61 (1949).
(8) B. Arakatsu and T. Hanatani, unpublished report (June, 1945).
(9) B. Araktsu, T. Hanatani, and K. Kimura, unpublished report (June, 1945).
(10) S. Okada, unpublished report (July, 1945).
(11) M. Kobayashi, unpublished report (July, 1945).
(12) Three members (Shimizu, Ueda, and Ishizaki), however, parted from the team and went to Iwakuni, 35 km southwest of Hiroshima, in the afternoon of the 14th, because they were very anxious to inquire the staff of the Iwakuni Base of Navy Air Force of the atmospheric condition above Hiroshima area in the morning of the 6th when the atomic bomb was dropped. They came back to Kyoto with samples and materials they collected at about 14: 00 p.m. of the 16th.
(13) The location of the epicenter was estimated by many workers. At present, as the most reliable location that estimated by H. H. Hubbell, Jr, T. D. Jones, and J. S. Cheka in 1969 is adopted. Upon examining many data so far published they estimated the location of the hypocenter as being situated at longitude 132°27′29″ E × latitude 34°23′29″ N with an error of about 15 m. This point is located on the ground of the Shima Hospital, 160 m southeast from the center of Atomic Bomb Dome. They also estimated the altitude of the burst point as being 580±15 m. (H. H. Hubbell, Jr., T. D. Jones, and J. S. Cheka, ABCC Technical Report 3-69 (1969)). Distances denoted in captions of Figs. 1-4 are values from this hypocenter. It is noted, however, that distances shown in Tables I, II, and III are those from the hypocenter presumed by our survey at that time. Our location is 130 m northwest from the present adopted location.
(14) Collection of Investigation Reports on Atomic Bomb Disaster, Vols. I & II, ed. Japan Science Council (Japan Society for Promotion of Science, Tokyo, 1953), in Japanese.
(15) HIROSHIMA AND NAGASAKI- The Physical, Medical, and Social Effects of the Atomic Bombings, ed. The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombs in Hiroshima and Nagasaki (Iwanami Shoten, Tokyo; Basic Books Inc., New York; Hutchinson Pub. Group Ltd., London, August 6th, 1981).