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from Dr. Bruner

EXPERIENCE OF AN ACCIDENTAL CONTAMINATION BY RADIOACTIVE MATERIALS - PALOMARES 1966 -

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On 17 January, 1966 an aviation accident happened during an in-flight refueling operation which caused the loss of a B-52 bomber and a tanker of the United States Air Force. The accident took place over the village of Palomares which belongs to the municipality of Cuevas de Almanzora in the Province of Almeria. Bits of the planes were scattered over a wide area corresponding generally to the area between the municipalities of Cuevas de Almanzora and of Vera, and the edge of the Mediterranean Sea between Puerto Rey and Villaricos. Palomares has about 1200 inhabitants and is situated on the right bank of the Almanzora River near its mouth and the beach. The village is not, properly speaking, an urban nucleus but is irregularly distributed to the point where there are no streets. Groups of houses or isolated houses are located at random over an extensive zone of uneven terrain which is crossed by a road, paths and innumerable ditches for the irrigation of gardens of neighboring farms. Tree growth is poor, but in the surrounding valleys and depressions irrigation farming is carried on over a wide area. The landscape is desert-like with broken and steep mountains between which lie the utterly dry beds of torrential streams; likewise the entire bed of the Almanzora River is dry. Vegetation is semitropical - data palms, century plants, prickly pears, holm oaks. Cultivated plants are mainly climbing tomatoes, broad beans, yellow corn, alfalfa, cereals and some orange and lemon groves.

On the Vera side of Palomares are wide areas of irrigated lands and orange groves, and toward Garrucha a semi-desert area. This zone is bound on the northeast by the Sierra de la Herreria and on the northwest by Las Algarrobinas. The coast opposite Palomares is flat and shallow; the beach, which is rocky, forms a slight arc from Punto del Rio to south of Garrucha. The climate is mild. Winters are warm and summers rather hot but with

soft sea breezes. Annual rainfall averages 200 L/m2 per year but is extremely irregularly distributed as it falls in only a few days, frequently causing overflowing of the dry beds of the Almanzora River and various ravines. Prevailing winds are from the east and southwest.

Agriculture is the wealth of the region with tomatoes as the most important crop at present, followed by broad beans and yellow corn. The climate permits at least two harvest annually. Offshore fishing is plentiful. Shellfish, cephalopods and various fish are the most important species and are in great demand in the nation's markets.

As a result of the aforementioned accident, four thermonuclear bombs which were being carried by the B-52 were thrown loose. Two fell with their parachutes open and so were found intact, one in the bed of the Almanzora River very near its mouth and one in the sea. The other two devices could not be recuperated intact as theirparachute did not open and the impact set off the conventional explosive contained in them. The resulting fragmentation and oxidation of the uranium and plutonium sponge which makes up part of the bomb created a cloud of those two elements. This cloud was dispersed and blown toward the sea by the strong prevailing SW-NE wind, contaminating an extensive zone as it settled out on the ground, plants and buildings. The hottest parts of this zone were the two impact centers : one a semi-desert hill 1.500 meters SW of the village on altitude-line 72 of Algarrobinas Hill; the other in some gardens at the extreme eastern edge of the village, about 200 meters from the nearest houses. In the inmediate area were found scattered about numerous mettalic bomb-fragments of varying sizes.

A check on the state of these two devices clearly showed a contamination problem caused by alpha emitters but no appreciable beta or gamma contamination.

Steps were inmediately taken which would enable us to determine the existence of a danger of inhalation of a radioactive cloud which, considering the characteristics of its elements, could justify evacuating part or all of the population of Palomares. Air samples were thus taken in various places in the town and in the fields, especially between the houses near the eastern impact area and in places where the surrounding atmosphere was most likely to be contaminated by the washing of radioactive elements deposited on the soil and on plants.

For this purpose the following equipment was used:

a) a mobile laboratory of the Medicine and Protection Division, a Volkswagen, type 22, equipped by "Frieseke and Hoepfner (Erlangen-Bruck, Germany)" and provided with, among other things, both a portable collector of dust samples model FH 422 with an

aspiration capacity of 30 cubic meters per hour, and a proportional counter of methane gas flux, model FH 407 A. Power was supplied by generators located in the back of the van.

b)Staplex portable air-samplers type TF 1 A with a sampling capacity of approximately 30 cubic meters per hour, powered by A.C. generators.

Because of its easy maneuverability, the mobile laboratory was used to collect air samples in various places in the vicinity of Palomares and Villaricos and in other places in a 6 km. radius of action. The Staplex air-samplers were situated in the most strategic parts of Palomares and in the two impact areas, and 30-minute samplings were taken. The position of the samplers was varied for each test within a 100 meter radius of action for each sampler.

The measuring of the alpha activity of the samples taken was effected in two parts: the first right away in order to acquire as soon as possible an idea of whether the alpha activity was much higher than the normal radioactivity caused by the descendents of radium and thorium in this zone; the second 24 hours later to determine the concentration in the air of emitters with a long half-life.

The readings showed that the concentrations of alpha-emitting elements in the surrounding air were not high enough to be considered dangerous or to justify evacuation. Except in places less than 100 meters from the impact areas, in the strong SW wind which blew between 3:00 PM and 5:00 PM on 20 January when no special decontamination measures had yet been adopted, the contamination value in the air were equal to or less than those considered as the maximum permissible for plutonium-239 by the International Commission on Radiological Protection (Maximum charge permitted = 6×10^{-13} microcuries/cm^3). In the abovementioned places and special circumstances, this contamination value was surpassed by only one factor of 100.

These first findings showed that:

- there was no problem of external radiation of persons;
- the biggest problem was possible internal contamination of the inhabitants of Palomares immediately after the accident as a result of breathing in of the radioactive cloud;
- possible external contamination of the inhabitants of Palomares, on clothes, skin and hair, could cause subsequent internal contamination if not eliminated as quickly as possible. This contamination could come from: a) direct contact with the radioactive cloud: b) direct contact with bomb fragments, bits of the planes, crops, the ground or any other possibly contaminated objects.

- the risk of later internal contamination by inhalation could remain constant if wind stirred up contaminated dust and kept it in the air;
- since the harvesting of some crops was in full swing in the contaminated areas, field workers could be contaminated internally and externally;
- contamination of the exterior of produce and foods could cause some internal contamination in case of ingestion, although the nature of the existing radioactive elements and the consequent slight intestinal absorption diminished the risk.
- besides the inhabitants of Palomares and others who were in the village in the moments immediately after the accident, the inhabitants of Villaricos could have been affected, as well as the curious came from other villages in the region and who crossed the various places where lay parts of the planes and of the material they were transporting. Many persons picked up small bits and kept them as souvenirs.
- contamination could be spread beyond the affected zone by contaminated persons, material and vegetable products leaving the zone.

Contamination of persons

In order to acquire a basic idea of the possibility of contamination of the persons in Palomares at the time of the accident, external contamination was determined first on those living in the houses nearest impact area number 3 and on those who, while not inhabiting those houses, were in a corresponding area at the time. The checks showed fairly unimportant external contamination values, the maximum being about 2000 D.P.M./100 cm^2 and being located mainly on footwear, lower parts of the trousers and sweater and jacket sleeves.

At the same time the external checks were being made, partial samples of urine were being taken from the same persons in order to determine the quantity of alpha emitters in general and of plutonium 239 in particular which was excreted. This would give a rapid idea of the extent of internal contamination, if any. The results of those tests and of the ones made 24 hours later on the same persons showed us that the quantity of plutonium-239 inhaled represented no immediate serious risk since the values obtained were below or only slighly above the minimum which corresponds to the maximum permissible dose as established by the I.C.R.P. (maximum permissible dose= .04 microcuries for bone as a critical organ and .4 microcuries for the whole organism as a critical organ). Also it was necessary to take into account that the sam-

ples of urine could easily be contaminated from the immediate external surroundings, giving a higher or erroneous evaluation of the internal contamination of the persons in question. This was verified by new tests performed on persons who remained under a rigid check in a completely contamination-free place after having been completely decontaminated externally. In one case in which the person was moved to Madrid because of a high contamination value and placed under daily checks for ten consecutive days, it was possible to ascertain that his dose could not be over 80% of the maximum permissible dose, considering bone as a critical organ, and that consequently and considering his age (76), there was no reason for serious preoccupation.

Once the external contamination checks wer finished on those persons who could be considered most affected, external contamination checks were started and carried on almost continuously for approximately 16 hours a day on the Civil Guards who had helped in the contaminated zones and on all the neighbors from Palomares, Villaricos and the villages of the region who had visited the scene of the accident soon after it took place.

These examinations were made for three main reasons:

a) for the tranquilizing psychological effect on the population when shown there was no external contamination. Unjustified collective panic could have begun without any real basis since completely erroneous information was given out for various reasons during the first days which created a certain uneasiness among the simple people of the village.

b) to detect contamination of clothing, skin and hair in order to set adequate norms of decontamination, if positive, or to collect the contaminated articles, if high.

c) to detect the existence and amount of external contamination on persons in order to determine which ones, even though they were not in a place where they might logically have breathed in the radioactive cloud, might have breathed in radiation later as a result of direct contact with the ground, vegetable products or contaminated material and so should be tested immediately, or later for internal contamination.

The first measurings of external contamination were taken on the spot with portable alpha activity detectors, model. 2672, from the Nuclear Chicago Corporation. On the second day two fixed detection units, type Integrateur Portatif Alpha Beta I.P.A.B. 2B from Nardeux Co (France) were installed in special quarters in the village and manned by two teams of two technicians each from the Medicine and Protection Division of the Nuclear Energy Board.

The results showed no appreciable contamination on the 1950 persons tested; only a small number showed contamination values of 2000 DPM/100 cm^2 and an even smaller number of 20.000 DPM/100 cm^2 on certain parts of their clothing, this group being the military personnel (Civil Guard) on guard duty in the most exposed zones.

The following measures were taken to avoid possible new external contamination, reduce the danger of inhalation from staying in contaminated places and prevent the spread of contamination to area away from those of the accident:

a) People were forbidden to enter the cultivated areas of Palomares as long as the contaminated zones were not marked off.

b) Interdiction to approach and look around the remains of the planes until they were proven not contaminated.

c) Blocking of the center of Palomares to curious outsiders until a low degree of contamination or the absence of it had been determined, etc.

d) The picking of tomatoes and broad beans, which was in full swing, was stopped until it was ascertained which ones could be picked without danger to the picker and the consumer.

e) It was forbidden to send to outside markets the tomatoes in stock and which had been picked after January 17th until they were proven not contaminated.

f) The foods stocked in the village were checked for contamination.

g) Vehicules entering and leaving the zone were checked.

Contamination of lands, vegetable products, water and houses

As soon as the remains of the two thermonuclear bombs were located, work began to determine the extension and degree of contamination in the soil, cultivated and wild plants, water reservoirs and houses in the village. For that purpose, once the geographical situation of the two impact areas and the distribution of bits of the planes were studied, a rapid field inspection was started to measure insolated alpha activity in the soil in order to get a general idea of the problem and organize the work of delimiting all contaminated areas. Consequently, the Palomares area was divided into three zones, two corresponding to the impact areas and which we shall call zones two and three, and the third, called zone five, corresponding to the town, which was between the impact areas, and which we predicted would be fairly well protected because of the wind direction at the moment of the accident. In areas two and three, measuring of superficial radiation was begun at the zero points of impact and covered 360 degrees of the surrounding land. The measurings were taken along radial axes 15 degrees apart, and soil

and vegetation were tested every 25 meters until about 100 meters beyond the point where the reading was zero. Thus was a "zero line" defined which was marked off by red flags to facilite quick and easy general recognition.

Once the zero line was fixed, the quantitative value of the contamination was determined more carefully on each of the marked-off parcels of cultivated land and on the crops in them. The same proceedure was followed on non-cultivated lands and on the wild vegetation and hills in the contaminated zones to establish lines of contamination of more than 710,000 DPM/100 cm^2 (500 micrograms of Pu 239/m^2), those between 710,000 and 7100, and those below 7100 in order to proceed in each zone according to the principles of treatment which were established and which will be mentioned below. These zones could not be established precisely because of the difficulties inherent in alpha activity detection in almost completely irregular terrain which is partly covered by rocks of widely varying sizes and by cultivated or wild vegetation. Thus radioactive particles were irregularly deposited, especially near the zero centers of impact where there were isolated spots where small bomb fragments showed activity of over 4 x 10^6 DPM. These were given special attention because of the risk that they could be picked up in the future by natives of the region, completely unaware of the danger, when there was no control or protection.

To determine the existence and degree of contamination in area 5, the urban nucleus of Palomares, the area was divided into four 90 degree sectors with the cinema as the center. Four teams of three persons each proceeded to examine the sectors, marking them off in 5 meter squares similar to the method used in prospecting for uranitic minerals. The investigation included streets, gardens, open spaces and cultivated areas between the houses, ponds, irrigation ditches, vegetation and houses. In all houses and especially those nearest areas where contamination was noted, the teams tested outside walls, roofs windows and embrasures. They also explored the interior of those houses whose inhabitants had kept bits of wreckage and of those nearest the impact centers, and their food stocks as well.

To measure superficial contamination, portable proportional counters with narrow windows were used, model PAC-IS from the Eberline Co. and model 2672 from the Nuclear Chicago Corp. Our experience has showen that even though the counters produce excellent results in laboratory work, their use in the field presents serious drawbacks because the physical characteristics of alpha radiation practically oblige the surface contact of the detector with the detected. This results in frequent contamination of the detector and, especially, perforation of the protec

tive film of the probe by contact with pebbles, needles and small branches, etc., which permits light to enter and thus renders the apparatus useless for measuring until the film is repaired or replaced, which causes great difficulties. That, together with the impossibility of detecting in a single measuring the amount of contamination on surfaces greater than 60 and 80 cm^2 respectively, the uneven distribution of the radioactive deposits and the irregularities fof the terrain made the fixation of alpha activity levels in the zone enormously laborious and slow. Therefore we feel that manufacturers of radiation detection equipment should be interested in solving this problem, especially for detection of plutonium and alpha emitters of similar toxicity.

The need for personnel specialized in the use of radiation detection apparatuses and measuring was very satisfactorily filled by safety personnel in the Nuclear Energy Board installations. In the field, the personnel of the Section of Prospecting for Uranilic Minerals, adapted to outside work and trained in radiometric sketches and manipulation of scintillation detectors of gamma radiation, was rapidly trained and fully conscious of its responsibility and the importance of the task.

To determine the contamination of certain vegetable products picked previously, of preserved foods, of certain places in the houses, etc., smears were frequently made with filter paper and measured in the proportional counter of flux in the mobile laboratory from the Nuclear Energy Board.

Besides the measurings of superficial alpha activity with the portable apparatuses mentioned, samples of soil and vegetable products were sent to the laboratories of the Medicine and Protection Division of the Nuclear Energy Board in order to have a more exact measure of the contamination values although the time required for it did not permit us to use the Laboratories in the emergency phase.

The result of all this work was the conclusion that an area of approximately 226 hectares was contaminated by alpha emitters, of which 2.2 hectares showed contamination of more than 700.000 DPM/cm^2, corresponding to the vicinities of the impact areas (1.6 hectares in zone 2 and 6 hectares in zone 3). Roughly 17 hectares were contaminated to a degree of between 700.000 and 70.000 DPM/100 cm^2, and the remainder, some 207 hectares, showed contamination of less than 70.000 DPM/100 cm^2 although more than half of this area was below 7000 DPM/100 cm^2. There are no habitually occupied houses in the maximum contamination areas, and most of the center of Palomares is in the minimum zone or outside the zero line. Only six houses were contaminated by more than 7000

DPM/100 cm^2, and that mainly in scattered parts of roofs, outside walls and window moldings, and in no case were the values greater than 20.000 DPM/100 cm^2.

Water samples taken from ponds throughout all the zones were tested for alpha activity in the mobile laboratory and later sent to our J.E.N. laboratories: they showed concentrations of about 10^{-9} microcuries/ml. Samples of sea water, taken in different places and at different depths and tested for plutonium activity, were likewise negative, as were samples of fish sent to Madrid for analysis.

We should indicate that the contamination registered on vegetable products was normally less than that found in the soil, except for alfalfa fields, and that because of the density of its vegetation. The radiometric map of zone 2 gives an idea of such a statement if one just observes the values obtained referring to counts per minute, measured with a PAC-1S detector of a 50% measuring efficiency and an effective surface of 60 cm^2.

Now, once the contaminated zone was delimited, a further area 4-5 kms wide around the zero line was tested and ascertained clean, except for the NE part where a strip of medium contamination, a prolongation of zone 3, was found behind the hills which border the river bed, 3 kms from the zero line. This area, quite rocky, showed alpha activity of less than 14,000 DPM/100 cm^2.

Decontamination

Because of the extension and characteristics of the contamination, the most serious problem was that of decontamination of the land to a point where there existed absolutely no risk to a future population which, throughout its life and for generations to come, and not because of war, could be endangered by internal radiation from an element which is considered at present one of maximum radio-toxicity. Because of the circumstances surrounding the contaminated zone, we could not think of adopting measures similar to emergency war measures, field operations or experiments which permit levels of superficial residue equal to or higher than those accepted in laboratories working with the same type of radioactive elements even though conditions and exposure times would be entirely different for the people involved.

Therefore, because the area was inhabited and cultivated, it was considered that very drastic measures should be taken since the norm generally recommended when dealing with a civilian population is to diminish by 1/10 the maximum permissible exposures. It had to be kept in mind that the life expec-

tancy of the population was 75 years, that there was little intercouse with the exterior, that local conditions could influence the natural rhythm of dissipation and that in case of contamination of food products, the problem of ingestion would continue as long as the products existed and could not be underestimated.

As a consequence of these consideration, of the results of previous experiments to determine the possibility of creation of a plutonium cloud and its content by starting from that spread over the surface of the land, of the characteristics of its mobility in the soil, plant absorption and absorption and inhalation by persons and animals, it was decided to carry out the following operations;

a) Collecting cultivated and wild vegetable products which showed a surface contamination greater than 700 DPM/100 cm^2, considering them as radioactive residues which must be checked and transfered to a final depository.

b) Elimination of layer of soil 5 cms deep in areas where surface contamination was greater than 200.000 DPM/100 cm^2, replacing it with well-fertilized earth from non-contaminated zones. The soil removed was considered as radioactive residue which had to be moved to a controlled and completely sure final depository.

c) Watering, plowing 30 cms deep, removing debris, raking, mixing and watering again of all lands showing contamination between 200,000 and 7000 DPM/100 cm^2 in order to eliminate contaminating plutonium from the surface and so dilute it in the soil that it could not cause any sanitary problems in the future.

d) Watering of and removing debris from cultivated lands having less surface contamination than 7000 DPM/100 cm^2 to make radioactive particles penetrate into the soil, dilute them and eliminate the possibility of their blowing away.

e) Washing of trees and bushes to eliminate contamination from their leaves and trunks, and uprooting those showing high activity and not responding satisfactorily to decontamination operations.

f) Hosing down with detergents of the houses where contamination was found, and if it did not drop to zero to a very low level, small residual zones were either chipped away and eliminated or painted over to fix the contamination.

Before these decontamination operations were undertaken, the most radioactive bomb fragments were located and picked up because they were big enough to be seen. This was effected by 50-men teams who searched all of the fields

advancing in line and one meter apart, investigating the plants and eliminating practically all alpha emitting elements which were not deposited as fallout. These men, like all those who assisted in the remainder of the contamination operations, were supplied with hermetically sealed suits, boots, gloves, caps and masks. They were decontaminated and issued new clothing after each shift, tested so they would not carry away the slightest external contamination and rigidly checked for internal contamination by urine samples.

Because of the extremely dry climate of the Province of Almeria, and in order to avoid the slightest chance of deposited alpha-emitting particles being suspended in the air, the deposits were at first fixed with mineral oil in and around the small craters where the contamination was greatest, and by abundant watering in other places where contamination was lower and the characteristics of the terrain and the slight cultivation favored the blowing and suspension of dust, and which was not necessary for future tilling.

Because of the nature of the crops which had to be collected, there were no machines available to cut or uproot them, so it was necessary to resort to the use of persons who first pulled up the stakes of the climbing tomatoes and then, supplied with sickles and protected by adequate equipment, cut and grouped the crops. Later, the reducing of the volume of the contaminated stakes caused great problems which were solved by using chopping machines similar to those used for cutting sugar cane.

The large number of century plants and prickly pears growing near the zero point of zone 3 had to be uprooted in order to eliminate the many highly contaminated fragments which were between their leaves and which would have been impossible to remove separately.

In order to remove the layer of soil previously mentioned without forming a radioactive dust cloud, the ground was thoroughly wet down by tank-trucks before and after being piled up by a bulldozer. The soil was loaded onto specially adapted trucks under special emergency conditions. The contaminated soil and vegetables were transported to a temporary depot in the more isolated zone 2 by a fleet of trucks fitted with hermetic drums which prevented loss and scattering on the way. They were unloaded under a curtain of water to prevent dust. The resulting heaps of earth were first watered continuously, then fixed by mineral oil and covered by firmly-attached nylon canvases. Once the contaminated soil was removed from zone 2, a pit was dug to reduce the volume of the huge quantity of green vegetable products which had been collected. Then the vegetables were brought in the special trucks, crushed by bulldozer or tractors, and covered with quicklime to destroy the organic matter. However, this treatment was less successful than hoped, perhaps because of the short time of contact available.

To prevent additional contamination of the trucks, the chassis, wheels, etc. were decontaminated as the trucks left an area that was being decontaminated or the depot area. For this purpose two intermediate zones were prepared and manned by teams equipped with powered pumps which shot a detergent and water solution, mainly an EDTA-based compound.

The plowing, crumbling, removal of debris and mixing of the soil of the cultivated fields was accomplished with tractors which were normally equipped for the work and rented from the farmers. The same farmers carried out these operations, provived with adequate protection equipment, and were completely decontaminated afterwards. Once the decontamination work was finished, checks of the land showed us that the desired result had been obtained. Since what really was accomplished by the first plowing was an inversion of active surface soil and inactive lower soil, it could be that later plowings could return the active soil to the surface. A repetition of normal tilling under the same conditions proved that the soil remained in the same state, perhaps more homogeneous and better mixed, and this contributed to the dilution of existing radioactive elements and the reduction of the risk of resuspension of radioactive dust. The theoretical factor of dilution achieved was approximately 4.2×10^7.

Trees, bushes and houses were treated by washing with water under high presure from pumps fitted on tank-trucks. Household cleaning equipment was sometime used on certain parts of the houses. Once the pertinent decontamination operations were finished in each of the parcels, zones, etc., teams and equipment similar to those used to delimit the contaminated areas tested anew the surface alpha activity of every parcel of the cultivated zone. If contamination greater than 220 DPM/100 $cm.^2$ were noted, another treatment would be made; otherwise the parcel would be returned to its owner along with a certificate stating that the land was in perfect condition to be worked again, and this was done.

Final deposit of radioactive residues

For the final deposit of all the radioactive residues which were foreseen, it was thought necessary to dig pits and bury them. These pits would have to meet several indispensable requisites which would assure indefinitely the impossibility of diffusion or escape of the radioactive elements contained therein and their penetration into the human biological cycle through water, food chain, etc. A site for the pits was chosen in zone 2 which had the advantages of being nearby and offering maximum security as testified by geological studies made by specialized personnel. The only drawback was its geographical situation on the Mediterranean belt which borders the alpine rise of the Andalusian Cordillera where there are many seismic movements.

But when the technical studies and those concerning the design, materials to be used and construction of the pits were finished, it was decided to transport the residues in question to the United States where they would be buried in the final depository area of the Savannah River Plant. Because of the difficulties that the transport and burial of the residues entailed, it was decided to pack them in iron drums of about 220 liter capacity. After testing the strength of the loaded drums and their tops, perpendicular metallic bands were placed to reinforce the tops encircling the drums tangentally, This made them safe.

The previously dampened soil was shoveled into drums, and a series of rollers was used which considerably eased moving the drums to each successive spot where an operation was performed. Great attention was paid to external contamination checks and decontamination if positive. The transport and shipment operations went smoothly.

Conclusions

From the experience acquired on this occasion which we believe to be unique up till now, we have deduced the following:

1) As one of us has already exposed at the Conference of this Organization in Geneva, it is evident that, in accidents in which nuclear risks are great, governmental Nuclear Energy Commission must advise and direct the operations since the technical problems encountered are complex enough to require highly specialized installations, equipment and personnel.

2) An accident of this sort implies a series of aspects of protection - sanitary, psychological, strategic, economic, engineering, and even legal - which require the existence of a union of various types of efforts and the application of measures so united as to form a logistical plan of adequate equipment and personnel for rapid use in all of the operations related to accidental radioactive contamination.

3) It is necessary to inculcate in people of every walk of life the idea that radioactivity is not uniquely and exclusively leagued with that of maximum danger of our times and with the monstruous effects of nuclear and thermonuclear explosions. Distintions must be made between the types of radioactivity, causes that can modify the danger, forms of protection, etc. Therefore we feel that it would be of great interest to publish articles of popularization to familiarize the entire population with the immense risk of uncontrolled use of radioactive isotopes and nuclear arms; to show that from the beginning of the nuclear era many efforts have been taken to investigate the mechanism of radiation and its biological effects, the causes that can convert potential danger into real dan-

ger to man, methods and equipment of control, methods and means of analysis to enable us to give an opinion on the amount of one or several radioactive elements that have caused internal contamination, the dose of radiation from them, and the consequent risk to the individual. The articles would also state what doses of radiation can be allowed under abnormal circumstances or short periods of time; the existence of scientifically calculated values of maximum permissible doses of radiation and maximum permissible concentrations in air, water and foods, and what that represents as far as we know today. The articles would furthermore note that since life has existed, all living beings have been subjected to a determined dose of natural radiation that is not peculiar to nuclear bombs, reactors and the equipment and materials that men who are dedicated to the investigation and application of nuclear power handle in most countries of the world and which are contributing to raise the level of human existence.

Discussion

Dr. Kinani(Syria) after thanking the speaker, wished to point out that the figures given in the course of the lecture, such as 7000 d.p.m., 20,000 d.p.m. meant little without knowing the computors geometry employed to count and measure radioactivity of soil or vegetables such as tomatoes or beans. Would the speaker specify on the type of counter and apparatus employed to count and measure radioactive contamination to which he had referred in the course of this very interesting paper. Dr. Iranzo in reply to Dr. Kinani stated that the figures he had given in respect of contamination had been expressed in terms of disintegration per minute per 100 cm^2 which took into account the various criteria of the counters used, such as efficiency, effective contact surface etc, so as to obtain and formulate data which may easily be compared to the maximum permissible values of surface contamination established by various national and international organizations for the protection against radiation. The only case where contamination values had been expressed in counts per minute referred to the radiometric plan of zone No.2 where the results expressed pertained to soil and vegetation. He had specified that the measurements had been taken with the PAC-1S counter with an average efficiency of 50% and surface efficiency of 60 cm^2.

Mr. Levine (U.S.A.), asked whether any illnesses due to radioactivity had been discovered either immediately or since. Dr. de los Santos (Spain) replied that there had been no problem of organic lesions due to the happily small amount of radiation, and that no pathological changes had been observed to date.