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PREFACE

The third International Symposium on Rockets and Astronautics was held on August 28-September 1, 1961 at Nippon Toshi Center, Hirakawa-cho, Chiyoda-ku, Tokyo. The meeting was planned by the Symposium Committee with Prof. N. Takagi, University of Tokyo, as the chairman.

Sixty-three papers including thirty papers by overseas participants were presented at the sessions dealing with space law, space medicine and biology, vehicles, propellants and propulsion, space science, instrumentation, reliability and some other subjects in rocket technology.

We should like to express our warm thanks to Mr. S, Mitsuishi, Mr. K. Yokoyama, Mrs. K. Arakawa, Miss Y. Horii, Miss. K. Yoshida, Miss. K. Takagi, Miss, Y. Tamura, and Miss. F. Imura for their assistance in editing the proceedings, and to the publisher Yokendo for taking the task of printing. Sincere gratitudes are also due to the following companies for thier financial supports to the Symposium and also to the present publication.

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Chapter I Space Law

1

THE PROBLEM OF LEGAL STATUS OF CELESTIAL BODIES

Michel S. Smirnoff

The last development in the field of space flight showed clearly to the lawyers that the moment when the mankind will land not only on the Moon but also on other planets had become only a matter of time, and perhaps of very short time. The significance of that fact, which is especially important after the landing of Lunik II on the Moon, is that for us lawyers a moment comes when we definitely have to study the problem of the legal status of the celestial bodies. This problem is so important that in the last time a numerous literature all over the world appeared on that matter.* Although the first papers dealt especially with the Moon, the last papers were devoted to the general problem of celestial bodies as an entity . It is quite natural when we think of the great projects which exist in almost all countries in the world and not only in USA and USSR regarding the plans of launching new satellites, rockets and spaceships with the aim to reach Mars, Venus and so on.

So now the lawyers are faced with the very serious problem of how to treat those celestial bodies, and what relations will exist between the first explores of which-soever country they come from and those celestial bodies. This problem is now on the program of scientific works of many juridical organizations and we only mention two of them namely the International Law Association and the International Astronautical Federation. The International Law Association discussed this problem in Hamburg during its 49th Conference and agreed on a Resolution as Follows:

> ".... 4. Recommends the conclusion of an international agreement whereby States would agree not to make claims to soverignty or other exclusive rights over celestial bodies, and affirm the principles of law stated in paragraph 3(a) and (b) of this Resolution,"
>
> The paragraph (a) and (b) being:
>
> (a) Outer space and celestial bodies should be utilized only for peaceful purposes to the greatest common profit of all mankind in accordance with the principles of the United Nations Charter;
>
> (b) Outer space may not be subject to the sovereignty or other exclusive rights of any State."

The International Astronautical Federation dealt with this problem in its III Working Group which has to answer following questions:

1. What theories have been advanced by recognized commentators as to sovereignty over celestial bodies?
2. What should be the legal status of the sun, the moon, the planets, and other natural objects in outer space?
3. Can individual nations obtain sovereignty over celestial bodies?
4. What acts are necessary to establish the sovereignty of a nation over a celestial body? For example, what would be legal effect of contact between: (a) a manned space vehicle and a celestial body; (b) an unmanned space vehicle and a celestial body?
5. What is the extent of sovereignty over a celestial body?
6. How far does the sovereignty in a celestial body extend beyond the physical substance of the body?
7. What theories have been advanced by recognized commentators as to property rights in celestial bodies?

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* We found 54 articles and papers in the bibliography on celestial bodies, prepared for the Report of III Working Group of IAF.

The Washigton Congress of IAF in October this year will discuss the Report of III Working Group(1) on that matter and probably give the instructions to that Group for further works.

The fact that two great world legal organizations put this problem on their Agenda proves its great importance. For us the significance of the studies of that problem lies in the dangers which exist in this problem if it is not timely solved. We Point out that for the moment we have a legal vacuum in the outer space and therefore every moment could bring the very serious conflicts between the peoples on the Earth on behalf of the activity linked with the celestial bodies. Meanwhile we consider that the duty of every lawyer is to avoid the possibility of such conflicts. With the very big natural resources which will be available in the celestial bodies the possibility of those conflicts seems to be perfectly real. On the very day of the landing of Lunik II on the Moon, the Soviet Academician L. Sedov and Topchiyev declared that the fact of landing Soviet emblemmas on the Moon does not represent any territorial claims on the Moon. But we do not know whether to-morrow all the nations which explore the celestial bodies will be willing to give such declarations.

Therefore in this paper before the distinguished audience of the III Outer Space Symposium in Tokyo we want to state some points which in our opinion are extremely important for the problem of the establishment of a legal status of celestial bodies.

1. We always thought that outer space was a res communis omnium and we think today that the celestial bodies are also res communis omnium. The logical consequence of that premise is that celestial bodies are not capable of any occupation or discovery which would lead to the possibility of the creation of right of sovereignty of an individual state on the Earth.

2. We take in account the possibility of the existance of intelligent living beings on the celestial bodies. In that case not only no right of sovereignty is possible for any individual state on the Earth, but the relations with those celestial bodies have to be established on the basis of absolute equality between those living beings and the mankind.

3. With a view to avoid any projection of our conflicts on the Earth into the Outer Space and on the celestial bodies we propose the creation of a specialized Agency of the United Nations which will be competent for everything pertaining to the outer space and celestial bodies. This Agency could exploit the resources on the celestial bodies itself or by the system of licences give this exploitation to other organization or corporations which will be under its control.

4. An international conference must be held in order to conclude an international agreement on outer space and celestial bodies on the basis of principles above expounded .

We do hope that the conclusion of such agreement will be possible and we think that after the conclusion of the Antarctic Treaty in 1959, the chances for the conclusion of Outer Space Agreement are even greater than before.

From the other side we are very afraid that if the mankind will not seize this opportunity to conclude this agreement at the very beginning of the space and celestial bodies exploration, later will it be more difficult to come to such an agreement. The national traditions will develop with further flights to celestial bodies and the question of prestige for the first success will spoil all the effects of an early international agreement. What will signify the legal vacuum in the problem of the legal status of celestial bodies is easy to imagine. The danger of projection of our terrestrial conflicts into the outer space will be imminent with the consequences which could only be guessed.

We have often heard the critics saying that the international agreement in the field of outer space is premature(2) owing to the fact that we do not dispose with all the documentation and knowledge necessary for a good condification. However, we should oppose to those critics considering that an international agreement which perhaps will not be absolutely perfect is better than a legal vacuum in this very sensitive region.

And our conclusion would be that the international agreement which we propose despite of all its imperfections would contribute much to the direction that space law becomes an element of understanding between the peoples on the Earth and not an element of disunion and conflicts.(3)

REFERENCES

1. Report of the III Working Group on the problemsof the legal status of celestial bodies, with Bibliography, p. 27, prepared for the IV Colloquium on Space Law, Washigton. October 1961.
2. Rear Admiral Chester Ward: "Projecting the Law of the Sea into the Law of Space," Legal Problems of Space Exploration, Washington, 1961, P. 120.
3. "Space Law as an Element of Understanding Among the people on the Earth," Paper presented by Dr. Michel Smirnoff to the IV Colloquium on the Law of Outer space, Washington,1961, October 3-4.

THE LEGAL STATUS OF PLANETS

Fumio Ikeda

(1) The successful flight of the Russian "Cosmonaut" is one of the most remarkable achievements ever made by a human being. However, Major Gagarin's exploit is, of course, only the beginning. Indeed, it is expected that the exploration and exploitation of the moon, as well as the planets, will be carried out in the near future. The soft landing os space vehicles on the moon has already actually been scheduled.

Such being the case, the question of the legal status of the moon has become a most urgent problem in relation to the legal requlation of outer space. The same questions will arise with respect to the planets in the Solar System with the advent of interplanetary intercourse.

Hitherto, it has been regarded as most unlikely that the question of acquiring title and rights to celestial bodies would arise in the near future. For instance, Prof. Jenks in his article "International Law and Activities in Space" published in 1956, considered it as one of the less immediate problems. Again, in 1958, a report submitted to the United States Congress filed it under remote problems. Furthermore, a report of the Ad Hoc Committee on the peaceful use of outer space in 1959 stated that problems relating to the exploration of celestial bodies did not require priority treatment.

However, in spite of these predictions, the advance in space science and technology has been so rapid and remarkable, that the solution to such problem has become a matter of great urgency. For this reason, I wish to make a few short comments on the subject.

(2) It appears to me that the most important problems relating to the legal status of the planets are as follows:

In the first place, what conditions are required, under existing international law, to make territorial claims to planets? Would the method of applying positive international law to this new situation be effective or fruitful? If not, there would then be a need for a new policy.

With the advent of the space age, some writers have discussed the problem of whether planets are to be regarded as "res nullius" or as "res omnium communis". However, there is presently no international convention or international customary law which provides to the latter effect. If planets are "res communis extra commercium" in any clear cut terms of law, our task will be a very easy one. But this is not the case and therefore the question still remains whether the legal status of planets is "territorium nullius", and consequently, susceptible to occupation. Therefore, we must first of all know what the logical process would be if the planets were to be regarded as "res nullius" under present international law.

International law recognizes occupation as the principal method by which a stats acquires title over a territory which is "res nullius" in law. Occupation must be effective to constitute a valid claim of sovereignty over a discovered area. And to be effective, two elements must be satisfied by the occupying state; namely, an intention or will to act as sovereign and some actual exercise or display of such authority. Historically speaking, at the time of the discovery of the American Continent in the fifteenth century, mere discovery did confer territorial sovereignty. But in the course of time, the rule of occupation was gradually formed. It continued to be an important rule until the partitioning of Africa at the close of the nineteenth century, when new rules of occupation were added by the Final Act of the Berlin

Conference in 1885, That Act imposed upon the signatory powers the obligation to notify other states of an intention to take over a territory. At the same time, Article 35 of the said Act required the existence of an authority sufficient to maintain order in the claimed territories. However, this Act has been abrogated in so far as the revision of the General Act of Berlin, made at St. Germain-en-Laye on September 10, 1919, applies.

What would then be the results if the rules of occupation, briefly sketched above, were applied to planets? Needless to say, in the present stage of space exploitation, mankind cannot actually exercise control of planetary territories; only in the future will this be possible. Therefore, the landing of the Russian rocket on the moon, as well as the success in taking photographs of the back of the moon, does not constitute actual possession. However, planets could be occupied and appropriated under existing international law if in the future, a state should exercise authority on planets with the intention of acquiring sovereigh rights over them. There is every reason for arriving at this logical conclusion because, as a matter of principle, rules of positive international law do not appear to be limited in their operation to the confines of the earth.

(3) Under present international law, actual taking of possession is, as argued above, a necessary condition of occupation. Degrees of actual possession vary with each case, especially under decisions of the present century when tribunals have been inclined to be satisfied with very little in the way of actual exercise of sovereign rights. This is particularly true in cases of claims to sovereignty over areas thinly populated or quite unsettled. The Island of Palmas (Miangas) Arbitration Case, 1928, the Clipperton Island Arbitration Case, 1931 and the legal status of Eastern Greenland Case 1931, are typical. These cases showed a readiness to accept as a test of territorial sovereignty something less than actual administrative control. Therefore, effective occupation does not necessarily imply that control is extended to the whole of the territory claimed. To be effective occupation is sufficient to dispose at some places within the territory of such a force whose power can be extended, if necessary, over the whole region, and to exclude any interference by a third state.

The same theory could be maintained with even greater conviction concerning planets so far as present international law is concerned. On September 12th, 1959, Lunik II of the U.S.S.R. carried to the moon three pennants, on the faces of which the national arms and the letters "C.C.C.P 1959" were engraved. Based on the theory above expounded, it would not be impossible for the U.S.S.R. to claim occupation of the moon, or at least the part of the moon on which the said pennants fell. This claim could not be considered unfounded when compared with the "Sector" theory relating to the acquisition of title to the polar areas.

However, it does not follow that the issue is completely free from doctrinal doubt. In the strict sense of positive law., there must still be effective occupation or some extended application of its effectiveness if the occupation is to be valid. Moreover, the U.S.S.R. has already declared that it entertains no intentions of making formal claims to the moon on the basis of the accomplishment of Lunik II.

(4) From a practical point of view, a far more urgent matter is to determine whether discovery itself gives any basis to territorial claims. Although the rule of discovery was replaced by the rule of effective occupation, the latter is nevertheless not without importance. That is to say, it gives to the discoverer an inchoate title. This title is a temporarily bar to occupation of the discovered territory by any other state for such a period as is reasonably sufficient for effectively occupying the discovered territory. If such period lapses without any attempt being made to occupy the territory, the inchoate title perishes. In other words,

such a title pre-supposes always an effective possession in the future by the state in whose name the discovery was made.

Would this theory, then, be applicable to planets? With regard to discovery, the Lunik III of the U.S.S.R. must be said to be most important. Lunik III, for the first time in human history took and transmitted back to the earth many photographs of the bach of the moon and provided important material for drafting a precise map of the back of the moon which was published in 1960 by the Soviet Academy of Science. It seems to me that this achievement by the U.S.S.R., under existing international law, is sufficient to constitute a basis for a claim to an inchoate title to the moon. Dr. Georg W. Rehm in Zeitschrift für Luftrecht und Weltraum-Rechtsfragen, Nr. 1. 1960 insisted that "auch im Augenblick der Entdeckung eine tatsächliche Herrschaftsausübung objectiv möglich sein muss", but his contention does not seem to me right. It is suffi cient for a valid discovery that later development of space technology make actual possession possible, even though effective possession be utterly absent at the time of discovery

Therefore, it is not correct to say that the U.S.S.R.'s Lunik III has no bearing whatsoever on an inchoate title. However, since the U.S.S.R. has not yet claimed any title to the moon, we can fairly conclude that nothing has so far been altered in the status of the moon.

(5) From the viewpoint of formal logic, it can be said that planets have been "res nullius" under international law because no state has hitherto appropriated them. On the other hand, it would also be possible to contend that the rules of positive international law should be extended to outer space, including the celestial bodies. Furthermore, a much lesser degree of effective occupation would be sufficient in the case of planets, considering that the requirement of effectiveness has been largely moderated in cases of unsettled islands as well as with regard to the polar areas.

Thus, on the basis of the contention above stated, it could be asserted that planets may be appropriated under the rules of occupation in international law. But, the weight to be given to this conclusion should not, it seems, be answered on the level of positivelaw theory, but on that of political considerations. What would be the result, if states could appropriate planets by application of the rules of occupation? At present only two states are capable of exploiting planets: the U.S.A. and the U.S.S.R. Rivalry between these two nations will inevitably extend the cold war on earth into outer space. However, occupation and exploitation of the planets is of vital importance to the other nations of the earth as well, and this could result in fierce competition for the appropriation of planets in outer space. Hence there would be a revival of the struggle for colonies.

Such being the case, the application of the rules relating to territorial claims developed under present international law to the appropriation of planets would greatly impede the exploration and exploitation of the planets for the benefit of mankind. The exploration of space should not be guided by the interests or ideas of a single sovereign nation but by the concept of "Home Sapiens" as a whole. Also, the situation requires an absolute prohibition of any military uses. In these premises the basic principles of the law of space are to be found. The concept "System of value beyond the law-Wertordnung jenseits des Rechts" suggested by prof. Dr. G. Rinck in his article on space law will be fruitful only when it recognizes the above premises.

Strictly speaking, the rules of occupation in present international law are in themselves nothing but historical rules corresponding to the politico-economic demands of the European nations for the acquisition of colonies in the then newly

discovered areas of the world. This historical context makes it impossible to apply these rules directly or even by analogy of to outer space. Prudence should be exercised to avoid neglect of the substantial basis on which norms of law are constructed. Thus, from the viewpoint de lege ferenda, it is coneluded that planets should not be appropriated by sovereign nations but should be controlled and administrated internationally for the common interest of mankind.

(6) To secure rule of law in outer space, including celestial bodies, internationalization of outer space in required. This brings therefore the problem of how international control of outer space can be systematized . To that end, a policy should be sought, not on an abstract basis but on a concrete basis adapted to present circumstances. The most obvious solution would be the creation of an international organ for the control of outer space. At the XIth International Astronautical Congress held in Stockholm in 1960, which I attended as a delegate of Japan, a draft' of an International Covenant for outer space, elaborated by Mr. J. E. Faria, was presented. In this draft Mr. Faria proposed the creation of a new department in the United Nations to be called the International Space Agency under the sole jurisdiction of the United Nations General Assembly. However, I would prefer a specialized agency at the intergovernmental level linked to the United Nations. It is to be noted that the functions and powers of the General Assembly of the United Nations provided in the Charter of the United Nations are limited, and that these limitations would inhibit Mr. Faria's proposal. One bureau or agency under the jurisdiction of the General Assembly could by its nature be insufficient for the control of outer space. The specialized agency which I am proposing should be powerful enough to be able to effect direct control of outer space and the planets and should be staffed by experts in space law and technology.

The establishment of such a specialized agency for control of the planets would require the sanction of an International convertion providing for its creation as well as establishing the principles under which the planets are to be exploited. There is an excellent recent prototype, that is, the Antarctic Treaty signed in Washington in 1959. That treaty provided for an international system for securing cooperation among nations as well as for peaceful uses of the areas by demilitarizing the Antarctic Continent. The conditions of the Antarctic Continent are of course greatly different from those of the planets. Nivertheless, appropriate analogies can be made to the spirit and construction of that Treaty.

In the Convention for outer space which is to be drafted, it should be provided that outer space, including the planets, shall continue to be used exclusively for peaceful purposes and that it shall not become the scene or object of international discord. Uses of a military nature should be forever prohibited. This principle of demilitarization and uses for peaceful purposes should be the basis of control of the planets. Further, there should be provision for the principle of international cooperation. Exploitation of the planets should not be monopolized by a few nations but should be carried out through international cooperation. The above are the fundamental problems, and detailed technical regulation of space exploitation should follow their solution.

CHAPTER II SPACE MEDICINE AND BIOLOGY

SURVEY OF RECENT CONTRIBUTIONS TO THE PSYCHO-PHYSIOLOGY OF WEIGHTLESSNESS

H. J. von Beckh

During the last decade numerous investigators studied psychophysiological reactions of humans exposed to short periods of weightlessness. Special attention has been given to neuro-muscular coordination, disorientation, motion sickness, oculoagravic illusions and circulatory phenomena.

Since human exposures to weightlessness of considerably longer duration have been recently possible, it is worth while to compare results and predictions based on early experiments with those of recent rocket flights.

It should be pointed out, however, that experiences, realized to date, are not sufficient evidence for excluding the possibility that weightlessness of very long duration such as that anticipated for true space flight could not present additional problem areas.

4

SPACE TRAVEL: SOME IMPLICATIONS OF EXPOSURE TO DAILY SUBLETHAL DOSES OF IONIZING RADIATION

Lawrence T. Odland, and Solomon M. Michaelson

1. Introduction

When the medical hazards of space travel are listed according to their importance (1,2,3), that of ionizing radiation occupies a position very near the top. As the other items in this list are relegated to differing magnitudes of import, following scientific advancements, radiation hazards will probably ascend the ladder of importance until they occupy the first place.

Much has been written regarding the biological effects of ionizing radiation (4,5,6,7), and certainly at the dawn of the space age, more was known about these than about those associated with acceleration, weightlessness, sensory perception deprivation, and many of the other factors which may impinge upon astronauts. The limits of mans' tolerance to these hazards are gradually being outlined, and within them, it has been possible to program successful space flights.

Radiation hazards stand alone as the one factor not subject to study in normal humans. "G" forces can be calculated, and, once applied to a man, leave no residual effects provided certain limits are obeyed. Weightlessness can be studied and experienced, albeit for short periods, many hours can be spent in sealed cabins, the gastronomic adventures of exotic foods enjoyed; but the astronaut cannot be exposed to significant amounts of ionizing radiation. Nor is it possible, at this juncture, to predict when and where a particular quantity and quality of ionizing radiation will be encountered.

Recent descriptions (8,9) of radiation "belts" surrounding planet Earth in a fashion related to its magnetic forces, are probably but the first steps leading to future discoveries of similar phenomena in space and in the environs of other cosmic bodies (10). In addition, unpredictable "solar flares" can "spill" large amounts of ionizing radiation into our solar system (10,11). It is not unlikely that other stars produce similar "radiation storms" equally unpredictable. Therefore, astronauts on a space journey, such as has been proposed to Mars (12), may, in the period of a few months or days, receive repeated sublethal doses of ionizing radiation.

This paper describes some of the findings in dogs after exposure to relatively large, but in most instances sub-lethal, doses of ionizing radiation, given in a manner similar to two (i.e. acute and chronic) possible sequences of encounters with this energy in space.

2. Materials and Methods

Each of 32 beagle dogs of both sexes were randomly assigned to one of six exposure groups. After routine screening by the colony veterinarian, a two week observation period followed, during which control data was obtained. Housing was provided by standard kennel quarters and nutrition by a recognized kennel ration, fed daily. Water was given ad libitum.

A one-million volt General Electric Industrial X-ray Generator was used as the source of ionizing radiation. The beam was unconed, and filtration consisted of only that inherent in the apparatus, viz; 1/12 inch tungsten, 5/16 inch brass and 13/64 inch of water. All exposures were made at a distance of 100 centimeters from the target to the midline of the animal. A dose rate meter* was used to monitor each exposure,

* -Radocon-Victoreen Instrument Company, Cleveland, Ohio.

the probe of which was placed vertically in the beam 2.5 cm above the spine of the dog at a point equidistant between the cricoid cartilage and the anal orifice. Using the anthropometric data of Roberts and Dahl (13), a confining box was built to house the dogs during the exposures and dampen their oscillations in the plane at right angles to the beam. No medication was given to sedate or tranquilize the animals. The longitudinal axis of the animal was positioned at right angles to the x-ray beam, and after one-half of the dose was delivered, the animal was rotated through 180° and the remaining radiation given. Table 1 gives details of exposure and doses used.

Table 1

Animal Groupings and Exposure Details

Group No.	No. of Dogs	Total Dose Roentgens	KV	Dose Rate/ Minute	MA	Frequency of Exposure
1	5	150	1000	9.3-9.5	0.5	37.50 r/day x 4
2	5	150	1000	52-53	3.0	150 r single dose
3	5	225	1000	9.3-9.5	0.5	56 r/day x 4
4	5	225	1000	52-53	3.0	225 r single dose
5	6	300	1000	9.3-9.5	0.5	75 r/day x 4
6	6	300	1000	52-53	3.0	300 r single dose

Hematology studies on each animal, consisting of white blood cell count and differential white cell count were done on days 1,4,7,14,21,29, 38,49, and 59 following exposure.

The dogs were weighed and their rectal temperature measured every day following the last exposure for the first 30 days, and then every 4 days thereafter to 60. Clinical observations were recorded at the time of these measurements.

Since the purpose of this study was to assay the functional impairment of the bone marrow following radiation, a radioactive isotope of iron, Fe^{59}, was chosen as a means of gauging this impairment. The rate at which iron disappears from the blood and subsequently appears in the circulating erythrocytes, depends partly on the rate at which iron is being used for the production of erythrocytes in the bone marrow, which in turn reflects the function of the entire marrow system. The method of Lentino, et al (14) was used to measure the time required for one-half of an intravenously administered dose of radioactive ferrous citrate solution to be cleared from the plasma. These time were determined on days 1,15,30, and 50 following the last exposure to radiation. Ten days following each injection of the tracer, a sample of venous blood was measured for radioactivity in a well-scintillation counter utilizing NaI crystal as the fluor. In this way, it was possible to estimate the percentage of each injected dose subsequently incorporated into new erythrocytes, as allowance was made for radioactivity remaining in the cells from previous injections of the isotope. A total of about 6 microcuries, representing approximately 1.0×10 mgm of iron, was injected per animal during the entire study period of 74 days. Radioactive samples were counted until a total of 10,000 disintegrations registered, the time for which never exceeded ten minutes. Standards prepared from the stock solution of radioactive ferrous citrate were counted with biological samples, thereby automatically correcting for radioactive decay of the isotope and changes in efficiency of the counting apparatus. Appropriate

corrections were made for background counts, which averaged 170-180 per minute.

An estimation of the total red cell mass was obtained by extrapolation of the plasma clearance curve to zero time and obtaining the venous hematocrit. This value was then calculated according to the following expressions:

$$1.\ \text{Plasma volume} = \frac{\text{Radioactive counts per minute per cc standard}}{\text{Radioactive counts per minute per cc plasma at zero time}}$$

$$2.\ \text{Blood volume} = \frac{\text{Plasma volume}}{1-(\text{Hct} \times 0.91)}$$

3. RBC mass = Blood volume - plasma volume

3. Results

A. Mortality

Deaths occurred in three of the six groups as shown in Table 2. Under conditions of exposure used, a single dose of 300 r*, measured in air at the midline of the animal, represents the LD-50/30 (16).

Table 2

Mortality During Sixty Days Following Whole Body Exposures to X-Rays

No. of Dogs	Total Dose in r	Mode Exposure	No. of Deaths	Day of Death Mean	Day of Death Median
5	225	Single dose	1	-	-
6	300	Single dose	2	14	-
6	300	75 r every 24 hrs. x 4	6	18	16

B. Morbidity

In the low dose groups no significant temperature elevation was observed. Body weight was decreased less in the fractionated group than in the single dose. Both recorded a weight at end of sixty days about 5% greater than their pre-exposure values.

Except in the case of the fatality, rectal temperatures in the 225 r groups did not vary greatly from control levels. Slight elevations occurred in both groups between the 10th and 12th post-irradiation days, and again on days 20 and 21. The non-survivor displayed a slightly elevated temperature on each day after the irradiation and on day 14 an abrupt rise to 105.5° F where it remained until death on the 17th day. Body weight changes followed dissimilar trends in the two groups. Whereas the animals receiving fractionated doses experienced a persistent increase

*r is used in this report as an abbreviation for roentgen, a unit x-ray of exposure dose.