Penetrating Radiation in Seven Free Ballon Flights.

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Last year I had the opportunity to investigate the penetrating radiation during two balloon flights. I reported on the first of these to the scientific meeting of Karlsruhe. In both flights no essential variation in the radiation could be observed up to heights of 1,100 meters.

Gockel, also, in two balloon flights, was unable to detect the expected diminution in intensity of the radiation with height. From this it was concluded that besides the γ radiation from the radioactive element in the earth's crust there must be another source of penetrating radiation.

Two Wulf radiation apparatuses of 3 mm, wall thickness were used for the observations.

Apparatus No. I had an ionization cell with a value of 2039 cc and a capacity of 1.597 cm. Apparatus No. 2 had a volume of 2970 cc and a capacity of 1.097 cm.

A charge loss corresponding to a decrease of 1 volt per hour thus represented an intensity of ionization of $q = 1.56$ ions per cc per second in Apparatus No 1 and $q = 0.7355$ ions per cc per second in Apparatus No. 2.

Whereas all observers of the penetrating radiation on the top of towers have always confirmed a decrease of the penetrating radiation, Gockel and I in balloon flights could not detect such a decrease with certainty. In order to obtain reliable mean values it was necessary to carry out observation in long– lasting flights at modest heights. Parallel observations with a third thin–wall apparatus were accordingly undertaken to determine if the soft rays behave like the intrinsic radiation.

Further attention had also to be given to the fluctuations of the radiation. Pocini, making parallel observations with two Wulf radiation apparatuses, detected during single hour reading intervals undoubted simultaneous fluctuations of the rate of discharge over land as well as over the sea. The cause of the fluctuations therefore clearly lay outside the apparatus and in the radiation itself. It was therefore very important to determine whether this kind of simultaneous fluctuation can also be observed in balloon flights. Since such observations can be carried out with the least difficulty in long–lasting balloon flights at the same height, I have made the major part of the observations during night flights.

The last and most important objective of this investigation was the measurement of the radiation at the greatest possible height. In the six flights orginating in Vienna the low–load capacity of the gases used as well as the poor meteorological conditions prevented us from achieving this objective. In a hydrogen flight from Aussing a.d. Elbe succeeded in carrying out measurements to a height of 5350 meters.

Before each flight, control observations were made for several hours with the three sets of instruments. In this procedure the instruments were attached to the balloon cabin in the same manner as during the flight.

In [Table 41–1] q_1, q_2, q_3 are the reading in ions per cc second of the penetrating radiation made with the instruments 1, 2, and 3 respectively.

Table 41 - 1 Trip (26–27 April 1912).
Balloon: “Excelsior.”
Pilot: Hauptmann W. Hoffory.
Observer: V.F. Hess.

NN	Time	Mean absolute m	Height relative m	Apparatus 1 q_1	Apparatus 2 q_2	Apparatus 3 q_3	q_3 (reduced)	
1	16^h 40 – 17^h 40	156	0	15.6	11.5	–	–	from the
2	17^h 40 – 18^h 40	156	0	18.7	11.8	21.0	21.0	take–off
3	18^h 40 – 21^h –	156	0	17.8	11.6	19.5	19.5	point in
4	21^h 30 – 22^h 30	156	0	17.8	11.3	20.0	20.0	the Klub–
5	23^h 26 – 0^h 26	300	140	14.4	9.6	19.4	19.8	platz.
6	0^h 26 – 1^h 26	350	0	16.2	9.9	17.4	17.9	Vienna
7	1^h 26 – 2^h 26	300	140	14.4	10.1	17.7	18.1	
8	2^h 26 – 3^h 32	330	160	15.0	9.6	18.2	18.7	
9	3^h 32 – 4^h 32	320	150	14.4	9.8	18.5	19.0	
10	4^h 32 – 5^h 35	300	70	17.2	13.2	20.6	21.0	
11	5^h 35 – 6^h 35	540	240	17.8	11.8	19.6	20.8	
12	6^h 35 – 7^h 35	1050	800	17.6	10.0	18.1	20.3	
13	7^h 35 – 8^h 35	1400	1200	12.2	8.8	17.3	20.3	
14	8^h 35 – 9^h 35	1800	1600	17.5	10.9	17.3	21.3	

The mean height of the balloon during any particular observing interval (as a rule, about an hour) was determined graphically from the barometric trace. A mean value for the height was then obtained from altitude above sea level of the particular spot under the balloon.

[Table 41–1] shows first of all that for small heights above the ground the radiation is really weaker than at the ground itself. If we compute mean values we obtain [Table 41–2].

Table 41 - 2

	App. No. 1	App. No. 2	App. No. 3	
Before ascent	$q_1 = 17.5$	$q_2 = 11.55$	$q_3 = 20.2$	ions/cc/second
140 to 190 meters above ground	$q_1 = 14.7$	$q_2 = 9.8$	$q_3 = 18.7$	ions/cc/second

The ion count differences are 2.6, 1.8, and 1.5. The mean difference is thus about 2 ions. This decrease of about 2 ions in the radiation is clearly due to the absorption by the air of γ rays of the radioactive material in the earth's crust. The above–mentioned difference of 2 ions represents about three quarters of the total ionizing power arising from the γ rays of the radioactive material in the earth's crust. The total γ radiation from the earth's crust must thus give rise to about 3 ions per cc per second in the zinc container.

(For the small height of 160 meters we may disregard the possible increase of radiation coming from above).

[The data for several balloon flights are omitted – Editors.]

In oder to get an over–all picture of the variation of the penetrating radiations with heights as given by the mean values, I have arranged all the 88 balloon observations that I have made of radiation intensities in vertical steps. Since in this procedure each mean value for a given height is computed from several individual values which were obtained under different conditions and which may be influenced by the temporal fluctuations already discussed, we must not except at this point to obtain a very exact picture of the variation of the radiation with increasing height. . .

[A discussion of some minor variations of the ion count near the earth's surface is omitted – Editors.]

We see that the γ radiation from the surface of the earth and the air layers close to the earth accounts for the excitation in the zinc containers of about 3 ions per cc per second.

At heights of more than 2,000 meters there is a marked increase in the radiation. It reaches 4 ions from 3,000 to 4,000 meters and 16 to 18 ions from 4,000 to 5,200 meters in two counters. The increase is even stronger in the thin–walled counter No. 3.

What is the source of this penetrating radiation which is observed simultaneously in the three counter? . . .

[Here Hess gives various reasons and cogent arguments for dismissing the earth's radioactivity as the source – Editors.]

The discoveries revealed by the observations here given are best explained by assuming that radiation of great penetrating power enters our atmosphere from the outside and engenders ionization even in counter lying deep in the atmosphere. The intensity of this radiation appears to vary hourly. Since I found no diminution of this radiation for balloon flights during an eclipse or at night time we can hardly consider the sun as its source.