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A LABORATORY INVESTIGATION ON THE RADIATION ERROR OF THE RADIOSONDE THERMOMETER

by

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Abstract

In the laboratory is investigated the two components of the radiation error.

The heating of the air in the radiation shield makes the greatest part of the radiation error of the Finnish (Väisälä) radiosonde. An improved radiation shield is constructed for redusing the error. The results of laboratory test shows only litle radiation error.

A laboratory testing was carried out with 11 different radiosonde types and the results are compared with the results of second radiosonde comparison at Payerne 1956.

1. *Introduction*

The radiation error of the Finnish radiosonde was first determined by RAUNIO [12] in 1937 from ascent and descent observations. VÄISÄLÄ [13] determined the radiation error from the temperature difference between day and night observations and developed a correction method. This method was completed by RAUNIO [6], who also took into account the relative change of the solar radiation in the stratosphere as calculated by VÄISÄLÄ [14]. The method permits a comparatively simple elimination of the radiation error, although this error is considerable [8, 15].

In some other radiosonde types the magnitude of the radiation error has been determined partly in the same way as in the case of the Finnish radiosonde and partly by means of laboratory experiments, as well as by calculation from known physical quantities. SCRASE [10], among others, has analysed and determined by calculation the radiation error of the British radiosonde. In his analysis, the radiation error ΔT is split up into two components, the temperature of the temperature-sensitive element T_e, the temperature of the air within the radiation shield, T_a, and that of the free air T being taken into account:

$$\Delta T = T_e - T = (T_e - T_a) + (T_a - T)$$

where the first member $(T_e - T_a)$ represents the radiation error of the temperature-sensitive element and the second member $(T_a - T)$ the warming of the air within the radiation shield.

It is easy to ascertain that $T_e - T_a$ results from absorption by the temperature-sensitive element of the direct and diffuse solar radiation and the radiation reflected from the inner surface of the radiation shield. The value of $T_e - T_a$ is thus dependent partly on the length of the radiation shield, partly on the reflecting power of its inner surface, and partly on the absorbing capacity of the temperature-sensitive element.

Since as a rule the radiation shield has the shape of a tube, it is readily seen that $T_a - T$ obtains two extremes between which will lie the values encountered in practice. In the case of a long tube it is obvious that, after a certain distance, the air flowing in the tube will attain the temperature of its surface (T_s), whereas, if the tube is extremely short, it cannot heat up the air that passes through it to any noteworthy degree. It is thus particularly important to discover the way in which the heating of the air in the tube takes place and the requirements which the radiation shield of the thermometer should satisfy in this respect. An investigation of this kind can be conducted in the laboratory and if the heating of the shield is effected by means of radiation, it will be possible to subject the second component of the radiation error, $T_e - T_a$, to laboratory investigation.

2. *The device employed in the laboratory investigation*

As long ago as 1940, Väisälä and Tommila, at the Ilmala Observatory, built a device for the laboratory investigation of the radiation error. It contains a source of radiation and a fan, with the aid of which an air flow equivalent to wind velocities between 0.3—5 m/s can be produced (Fig. 1). In the beginning, difficulties were experienced in working with this device, because the intensity of the radiation from the source originally used was too low, only about 0.2 cal/min cm^2. It could be used to full advantage only later, after the present author had installed a

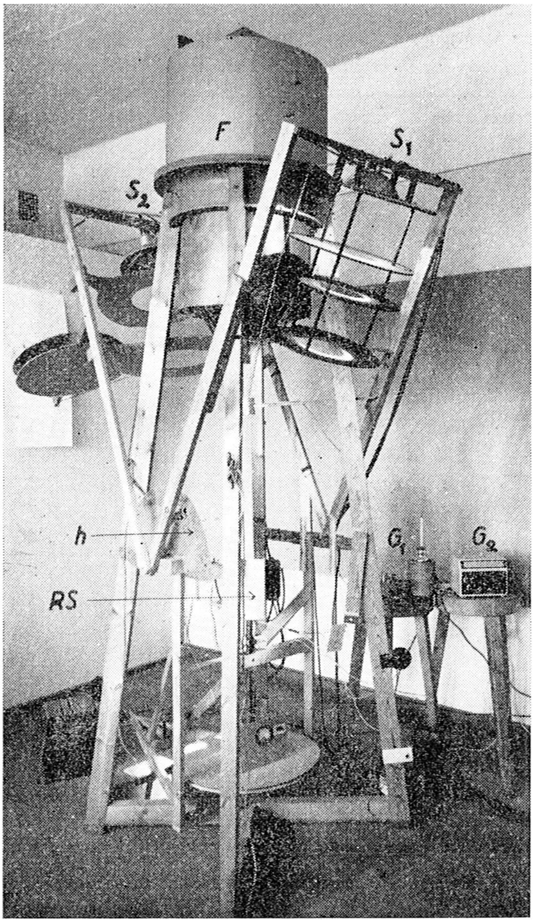


Fig. 1. The device employed in the laboratory investigation of the radiation error. F=fan, S_1=car headlight (2 cal/cm^2. min), S_2=radiator (0.2 cal/cm^2. min), RS=radiosonde (Lang), h=angle of elevation, G_1 and G_2=galvanometers.

car headlight with a radiation intensity of about 2 cal/min cm^2 at the distance to be investigated and further complemented it with an electric radiator producing about 0.2 cal/min cm^2. The radiosonde under investigation, or any other object, can be placed in an air current of variable velocity. It is also possible to change the position of the heaters so that their radiation will impinge upon the objects investigated at different angles of elevation. The object can be made to revolve around an axis usually parallel to the direction of air flow; the position of this axis can also be

Table 1. Temperature differences T_a—T between the air within a single tube and the outer air at different points within it, for various air velocities and various temperature differences T_s—T between the inner surface of the tube and the outer air.

Distance from inlet of tube		30 mm		75 mm		110 mm	
T_s—T °C		4°	33°	5°	32°	5°	33°
Distance from wall of tube							
0.3m/s	2.5 mm	1.6	—	2.1	—	2.3	—
	5	0.1	—	0.7	—	1.7	—
	7.5	0.0	—	0.1	—	0.8	—
	10	—	—	0.0	—	0.5	—
	15	—	—	—	—	0.3	—
0.7m/s	2.5 mm	0.4	1.6	0.6	5.3	1.1	6.7
	5	0.1	0.6	0.2	1.9	0.5	3.0
	7.5	0.0	0.4	0.1	0.9	0.3	1.4
	10	—	0.3	0.0	0.7	0.2	0.9
	15	—	0.0	—	0.6	0.2	0.7
1.0m/s	2.5 mm	0.4	1.3	0.6	3.8	0.8	5.2
	5	0.0	0.1	0.1	1.2	0.4	2.2
	7.5	0.0	0.0	0.0	0.4	0.1	0.5
	10	—	—	—	0.1	0.0	0.3
	15	—	—	—	—	—	0.1
2.0m/s	2.5 mm	0.1	0.1	0.2	0.9	0.4	1.6
	5	0.0	0.0	0.0	0.2	0.2	0.3
	7.5	—	0.0	0.0	0.0	0.0	0.2
	10	—	—	—	—	0.0	0.0
	15	—	—	—	—	—	—

changed while the object retains its location in relation to the radiators. 2—3 thermocouples may be fitted in the device for the purpose of temperature measurements.

3. *The heating of air in a tube*

Single tube

In order to study the heating of air in a tube, a tube of the dimensions 30 × 48 × 150 mm was made and placed on the specimen support in such a way that the air flowed in the direction of its longitudinal axis. The radiation was arranged to be perpendicularly incident upon the wall of the tube. Several different ventilation rates were used; this provided an oppor-

Table 2. Temperature differences T_{s1}—T between the inner tube and the air in a double tube at different air velocities when the temperature difference between the outer tube and the air is 33°, 31, 27 and 23°C at air velocities of 0.3, 0.7, 1 and 2 m/s, respectively.

Distance from the inlet of the tube			5 mm	30 mm	75 mm	110 mm
Distance between the inner and outer tube	5 mm	0.3 m/s	19.9	20.4	19.9	17.4
		0.7	4.2	5.3	6.4	8.5
		1.0	2.3	2.7	5.2	6.1
		2.0	0.6	1.0	1.6	1.8
	10 mm	0.3 m/s	9.9	11.0	10.9	10.5
		0.7	2.0	2.4	3.0	3.2
		1.0	0.8	1.3	2.2	1.8
		2.0	0.4	0.5	0.7	0.8
	15 mm	0.3 m/s	4.3	4.9	5.9	6.2
		0.7	1.2	1.4	1.6	1.7
		1.0	0.7	0.6	1.0	1.0
		2.0	0.5	0.4	0.5	0.4

tunity to obtain an idea of the influence of ventilation upon the heating of the air inside this radiation shield. First, let us consider the two cases where the outer surface of the radiation shield was bright and painted black, respectively, since remarkably different temperatures of the surface of the radiation shield (T_s) were obtained in these two cases. Table 1 gives the temperature difference T_s—T between the inner surface of the radiation shield and the external air, as well as the temperature differences T_a—T arising in the air flowing within the radiation shield at certain distances from the inlet of the radiation shield and from its wall. It is seen from the table that the heated air layer increases in thickness with increasing length of the tube. The thickness of the heated air layer is also clearly dependent on the velocity of the flow, increasing with decreasing air velocity. Zero temperature difference T_a—T obtains consistently farther from the wall of the tube with reduced ventilation and with increasing distance of the point of measurement from the inlet of the tube. It is quite obvious that the heated layer increases in thickness with increasing temperature difference T_s—T.

It can be concluded from the observations made on a single tube that the air temperature at the centre of the tube remains the same as that of the external air far into the tube. The wider the tube, the farther into it will the inflowing air represent the true temperature of the external air.

Double tube

In order to study the heating of the inner tube when the radiation shield consists of a double tube, the tube described above was encased in another tube and placed at various distances from its wall. The outer tube was blackened in order to obtain a high surface temperature. The outer tube was placed at 5, 10 and 15 mm distance from the inner tube, and experiments were carried out with the air velocities 0.3, 0.7, 1.0 and 2.0 m/s. The temperatures of the inner tube observed at various distances from the inlet of the radiation shield are shown in Table 2.

As can be seen from Table 2, the temperature difference between the inner tube and the air is essentially dependent on the air flow velocity and likewise on the distance from the outer tube.

On comparison of the results in Tables 1 and 2, it is astonishing to notice that in the case of a double tube the temperature of the inner tube is considerably higher than the air temperature within a single tube at the same distance from the outer tube. This can probably be interpreted as resulting from the turbulent flow arising in the comparatively narrow air layer between the tubes, which transfers heat from one tube to the other. Consequently, the use of two tubes, one within the other, as a radiation shield would appear less expedient than the use of a single tube equivalent in size to the outer tube.

In order to study this question in detail, one may also attempt to apply the results in Tables 1 and 2 in practice. In radiosonde observations the velocity of ascent of the balloon is, as a rule, about 5 m/s. Taking this into account, we may reduce the velocities employed in the laboratory (2, 1, 0.7 and 0.3 m/s), which correspond to earth level pressure, to the 350, 160, 110 and 50 mb levels, respectively, and the figures in Table 1 would thus give, in a way, relative values for the radiation error. Since the surface temperature of the radiation shield was rendered as high as possible in the laboratory experiments and does not, therefore, correspond to natural conditions, this has to be allowed for in practical applications of the results.

4. *The radiation error of the thermometer of the Finnish* (VÄISÄLÄ) *radiosonde according to laboratory tests*

The Finnish (VÄISÄLÄ) radiosonde was the first to be subjected to laboratory investigation. The design of its thermometer element and radiation shield, as used in the tests performed by VÄISÄLÄ and RAUNIO, is shown in Fig. 2. The radiosonde was inserted in the testing device and made to revolve around an axis parallel to the air flow. The air flow velocity 0.7 m/s was used in this experiment, and from the observed temperature differences T_e—T the average temperature difference T_e—T was calculated. The correlation of the resulting values with the angle of elevation of the radiator is shown in Fig. 3. The same figure also shows the radiation error of the thermometer in the Finnish radiosonde, as determined by RAUNIO [6] partly from day and night observations and partly from observations made during the total solar eclipse for 100 mb pressure and 300 m/min ascent velocity. As can be seen from this figure, closely similar values for the radiation error were obtained in the laboratory and under natural conditions, although some discrepancies can be noted. The latter may be due to the fact that the radiosonde swings and rotates during its ascent, for which reason its position in

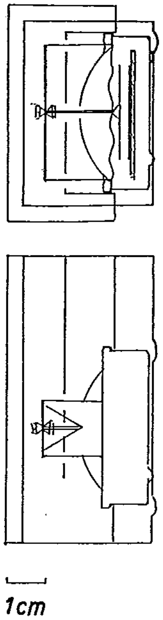


Fig. 2. The termometer and radiation shield of the Finnish (Väisälä) radiosonde.

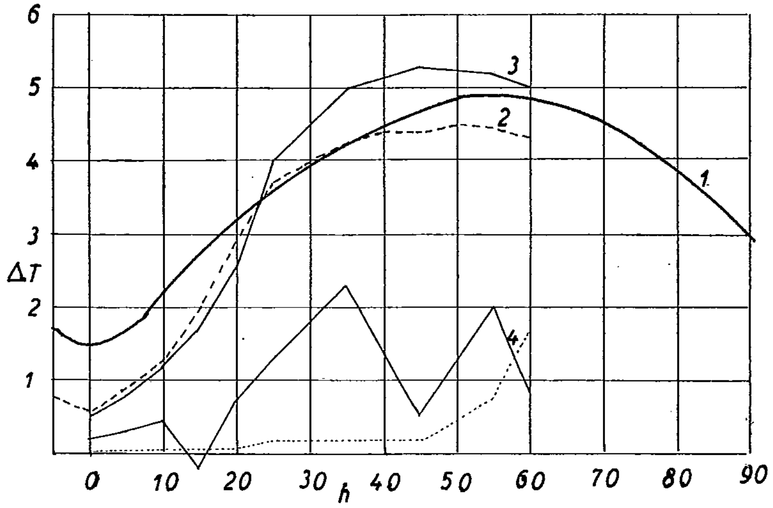
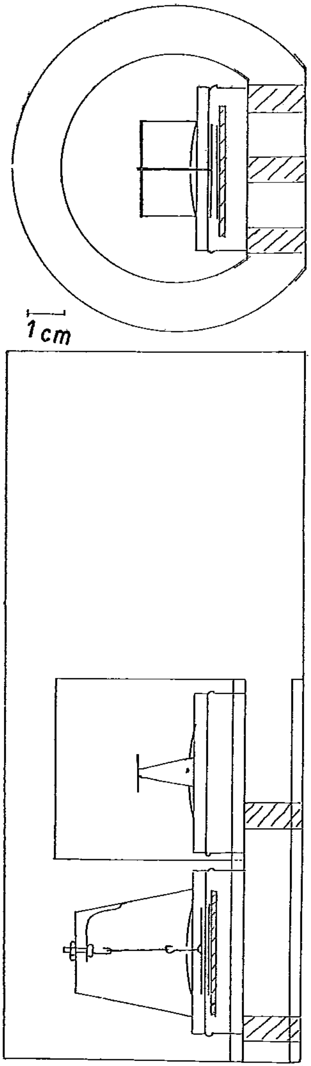


Fig. 3. Values of the radiation error. 1=day-night difference according to RAUNIO, 2= T_e—T with rotating radiosonde, 3= T_e—T and T_e—T_a, 4= T_e—T with the improved radiation shield.

relation to the sun changes at the same time as the direction of incidence of the sun's rays varies, whereas the elevation angle of the radiator is constant throughout the laboratory test. The observations made in the laboratory investigation may further include effects which do not manifest themselves in the atmosphere. Nevertheless, it can be noted that the value obtained in the laboratory for the radiation error shows close agreement with that observed under natural conditions.

If one considers the heating of the air within the tube (Table 1), it seems evident that the radiation error of a radiosonde thermometer of similar design is mainly caused by the heating of the air inside the tube. An attempt was therefore made in the laboratory experiments to determine both T_e—T_a and T_a—T separately. The thermometer of the radiosonde measures the value of T_e, and a thermocouple is thus necessary for the measuring of T_a. The observations were made with a stationary radiosonde, and the results are thus not fully comparable with the results of the preceding series of experiments with the revolving radiosonde. For the measurement of T_e—T_a, one thermocouple junction was glued to the bimetal, while the other junction was placed 3 mm above the same. However, difficulties were encountered in these observations for the reason that the thermocouple employed has a certain radiation error of its own, as the author has shown [8]. The observations were made in two different positions at various elevations of the source of radiation. In one of these positions the bimetal was perpendicular to the incident radiation and in the other position parallel to the radiation. The results are shown in Table 3. It is seen from these values that reliable results of observation are obtained only at small elevation angles. At angles in excess of 15° an uncertainty may occur in the difference T_e—T_a, due to the radiation error of the thermocouple, which is probably ±0.8°C at most. The results further reveal that the magnitude of the radiation error is different according to whether the radiation is perpendicularly incident on or parallel to the bimetal. Since the temperatures developed in these two positions differ by several degrees centigrade, here is an obvious cause of uncertainty in the radiation error during actual radiosonde observations. Still, critical scrutiny of the results conveys the fairly certain conviction that heating of the air within the radiation shield, T_a—T, is responsible for the greater part of the radiation error. About one-third of this error is caused by the heating of the thermometer itself, T_e—T_a.



Fg. 4. The improved radiation shield.

5. *An improved radiation shield*

It can be seen from the laboratory investigation described in the foregoing that a considerable reduction of the radiation error can be effected by reducing the heating of the air that flows within the radiation shield. Taking into account the results obtained with a single tube, this can be achieved in such a manner that the radiation shield is made wide enough to prevent the air heated up in the vicinity of the wall from coming into contact with the bimetal strip. The simplest means to reduce the other component of the radiation error, T_e—T_a, is to paint the inner surface of the radiation shield black and to make the upper part of the shield, which extends above the temperature-sensitive element, long enough to prevent any considerable amount of direct radiation from striking the temperature-sensitive element. The construction of the thermometer with radiation shield must be symmetrical. However, in a case where the above-mentioned conditions are very completely satisfied, symmetry obviously has no great significance.

An improved radiation shield was designed in accordance with these principles (Fig. 4). It has given good results in tests performed in the laboratory, and it has later been modified to suit the new radiosonde model [9]. The new radiosonde was then subjected to the same tests in the laboratory as the old type, the results being shown in Table 3. It is seen that the radiation error is < 0.2°C at elevation angles below 45° and in conditions corresponding approximately to those at the 100 mb level. At elevations greater than 45° the radiation error increases, owing to the fact that the radiation is then reflected by the bright inner parts within the

Table 3. The results (T_e—T) of laboratory tests of different radiosondes in two different positions and with different elevation angles of the radiators.

	Belgium			Deutsche Bundes republik			Model Lang			Finnish (Väisälä)			Finnish (improved)			France		
h°			Mean			Mean			Mean			Mean			Mean			Mean
0°	0.2	0.3	0.2	0.1	0.1	0.1	0.4	0.0	0.2	0.3	0.8	0.5	0.0	0.0	0.0	0.8	0.3	0.5
5°	0.3	0.3	0.3	0.1	0.1	0.1	0.4	0.0	0.2	0.4	1.3	0.8	0.0	0.0	0.0	0.7	0.3	0.5
10°	0.3	0.4	0.4	—	—	—	0.5	0.1	0.3	0.7	1.6	1.2	0.0	0.1	0.0	0.7	0.3	0.5
15°	0.4	0.5	0.5	0.2	0.2	0.2	0.5	0.1	0.3	1.2	2.3	1.7	0.0	0.1	0.0	0.7	0.4	0.6
20°	0.6	0.5	0.6	—	—	—	0.6	0.1	0.4	2.2	2.8	2.5	0.0	0.0	0.0	0.7	0.4	0.6
25°	0.7	0.5	0.6	0.2	0.2	0,2	0.9	0.3	0.6	4.9	3.1	4.0	0.2	0.1	0.2	1.0	0.3	0.6
35°	1.0	0.5	0.7	0.2	0.2	0.2	1.8	0.5	1.1	7.0	3.1	5.0	0.2	0.2	0.2	1.0	0.5	0.7
45°	1.3	0.7	1.0	0.2	—	—	2.2	1.0	1.6	7.5	3.1	5.3	0.3	0.2	0.2	1.2	0.7	1.0
55°	1.4	0.7	1.1	0.3	0.2	0.2	3.0	0.8	1.9	6.7	3.7	5.2	1.2	0.4	0.8	1.4	1.1	1.3
60°	1.4	0.7	1.1	0.3	—	—	2.1	0.6	1.8	5.4	4.6	5.0	3.8	0.5	2.2	1.2	1.2	1.2

	Japan			India (fan)			United Kingdom			USSR			India (chronom)			Poland		
h			Mean			Mean			Mean			Mean			Mean			Mean
0°	0.3	0.5	0.4	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.2	0.3	0.9	0.9	0.9	0.3	1.7	1.0
5°	0.3	0.6	0.4	0.0	0.1	0.0	0.3	0.4	0.4	0.3	0.3	0.3	—	—	—	0.6	1.7	1.2
10°	0.3	0.3	0.3	0.1	0.1	0.1	0.3	0.6	0.5	0.4	0.4	0.4	—	—	—	0.9	1.9	1.4
15°	0.3	0.3	0.3	0.1	0.1	0.1	0.4	1.1	0.8	0.5	0.5	0.5	1.0	0.9	1.0	0.9	2.0	1.5
20°	0.4	0.3	0.4	0.1	0.1	0.1	0.4	2.0	1.2	0.5	0.5	0.5	—	—	—	1.6	2.2	1.9
25°	0.4	0.4	0.4	0.3	0.3	0.3	0.5	3.1	1.8	0.5	0.6	0.6	1.0	0.9	1.0	1.2	2.9	2.1
35°	0.5	0.3	0.4	0.3	0.4	0.4	0.8	2.4	1.6	0.8	0.9	0.9	1.2	1.1	1.2	1.6	3.6	2.6
45°	0.6	0.8	0.7	0.4	0.5	0.5	1.1	3.3	2.2	1.5	1.2	1.4	1.7	1.3	1.5	2.5	3.7	3.1
55°	1.3	1.1	1.2	1,5	0.4	1.0	2.0	3.5	2.8	2.1	1.6	1.9	2.0	1.8	1.9	2.4	4.2	3.3
60°	1.3	1.3	1.3	3.1	0.9	2.0	2.4	3.9	3.2	3.3	1.9	2.6	1.7	1.8	1.8	2.2	4.8	3.5

shield. If the blackened part is made longer, remarkably low values of the radiation error will be obtained even at greater elevation angles.

Actual observations have given results with the above-mentioned radiation shield well in agreement with the laboratory experiments [9].

6. *The results of laboratory experiments with radiosondes of different types*

A similar laboratory investigation to that performed with the two radiosonde types mentioned in the foregoing was carried out with radiosondes of every available different type, one of each. These radiosondes

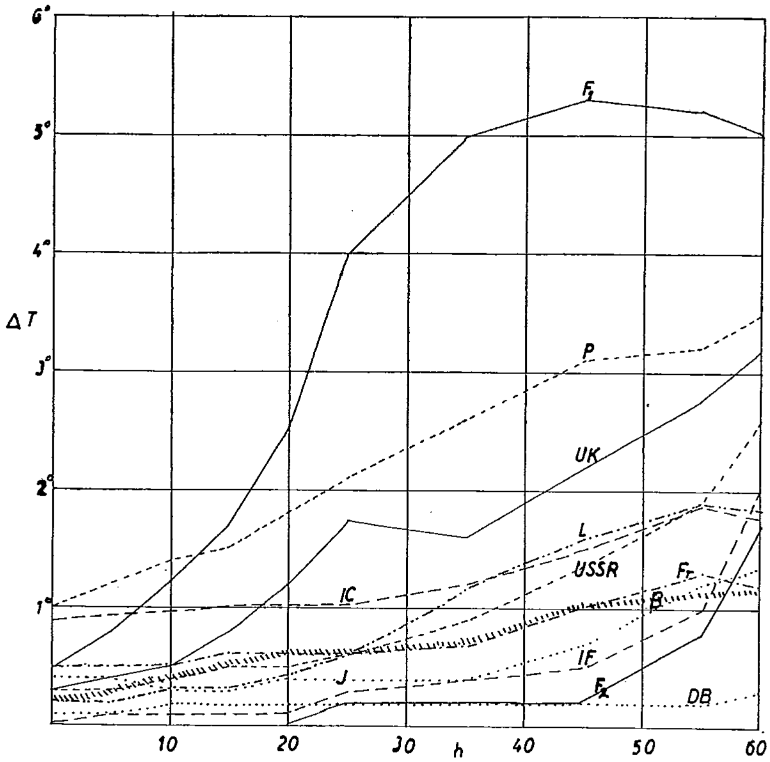


Fig. 5. T_e—T of different radiosondes in laboratory tests.

had been obtained in connection with the second international comparison of radiosondes at Payerne in 1956 from the participants from different countries. Since only the radiosondes without appropriate receiving equipment were available, the difference T_e—T could only be measured with the aid of thermocouples. One thermocouple junction was glued to the thermal body and the other was placed in the free air. However, the investigation could not be performed on the Dutch, Swiss and U.S.A. radiosondes, since their thin thermometer elements did not permit the use of this procedure. Difficulties were encountered in investigating some radiosondes of large size, for instance the French, Belgian, Russian, and Japanese radiosondes, because it is difficult to produce homogeneous radiation over a large area and this may introduce a factor of uncertainty in the observations.

The observations were made in two positions, at right angles to each other. An endeavour was made to choose the positions in such a manner that the observations would yield the potential extremes of the radiation error. The results are shown in Table 3 and Fig. 5. They reveal that in radiosondes with a large radiation error this error is highly dependent on the elevation angle of the source of radiation (the sun).

As the results obtained with the Finnish radiosonde show, the laboratory tests yield values in good agreement with the observations made in nature (Fig. 3). However, at small angles of elevation the radiation error is smaller in the laboratory observations than in nature.

When such a comparison is instituted between the results obtained with the British radiosonde in the laboratory and the radiation error values published by SCRASE [11], it is seen that up to elevations of 50° the values found in the laboratory are smaller than the radiation error values. The results obtained in different ways show greater mutual differences than the corresponding results obtained with the Finnish radiosonde; this may be due to the fact that no receiver was available for the British radiosonde and the temperature was measured with a thermocouple.

With the French radiosonde, the values obtained in the laboratory are considerably smaller than the radiation error values calculated for this type. Moreover, the dependence of the angle of elevation, as found in the laboratory experiments, does not agree with the calculated radiation errors. As the difference is of considerable magnitude, it would be interesting to subject the matter to closer investigation, and at the same time the receiver should be available.

The values obtained in the laboratory with the Japanese radiosonde show that the radiation error is dependent on the angle of elevation of the sun to a relatively small degree only. The value of the radiation error determined by HAYASHI [2] is qualitatively similar but larger than that indicated by the laboratory results.

It would be highly interesting to compare with each other the results found in the laboratory and those obtained at the comparison of radiosondes at Payerne in 1956. Results relating to the radiation error are available in the studies of DELVER [1], KITAOKA [3], MALET [4], PERLAT [5] and VÄISÄLÄ [15]. However, their values are mutually at variance, owing to somewhat different methods of treatment. In order to obtain the value required for the said comparison, an attempt has been made to combine the above-mentioned results, with which purpose the fundamental idea of each investigation has been taken into account. For the different radiosonde types, DELVER [1] has calculated the value of the

Table 4. The radiation error ($\triangle T°C$) of different radiosondes at Payerne 1956. ($h \sim 45°$).

mb	100	70	50	mb	100	70	50
B	0.9	1.3	2.5	IF	2.8	3.5	6.4
DBR	1.2	1.6	2.2	UK	2.7	3.7	5.8
L	2.3	3.0	4.7	H	3.3	3.6	—
USA	0.9	1.2	1.8	Sw	0.9	1.6	3.6
Fi	4.4	5.8	8.4	USSR	4.3	5.8	7.0
Fr	3.4	5.1	7.4	IC	2.6	2.8	3.8
J	1.6	2.4	3.4	P	5.1	8.8	10.2
Fi*	3.8	5.4	7.7	J*	1.3	1.8	2.6
Fr*	4.2	7.6	11.7	UK*	2.9	4.0	5.7

*calculated

so-called relative radiation error, this term referring to the deviation of the radiation error of each individual type from the mean of the radiation errors of all investigated radiosondes. KITAOKA [3], again, computes the deviations from the values obtained with the Japanese radiosonde from which the radiation error has been eliminated. MALET [4] and PERLAT [5] use the DB and USA radiosondes as a basis of comparison and compute the radiation error as the deviation from the mean obtained with these sondes. VÄISÄLÄ [15] mainly bases his investigation on the difference between day and night observations.

Among the above-mentioned results, the numerical values presented by KITAOKA and by VÄISÄLÄ can be used in parallel and they can be employed to determine the actual radiation error if the radiation error of the Japanese radiosonde is taken into account. A study of the result obtained in this manner reveals that the reference sondes employed at the Payerne comparison, DB and USA, show radiation error at the 100-mb level and above this level. For the magnitude of this error the mean values found by VÄISÄLÄ have been assumed, i.e., 31% and 23% of the radiation error of the Finnish sonde for the DB and USA sondes, respectively. From the calculated values the mean has been computed (100 mb 1.0°C, 70 mb 1.4°C, and 50 mb 2.1°C) and this has been used for the conversion of MALET's and PERLAT's results. Similarly, the vaules of DELVER's relative radiation error can be converted on the same basis into radiation error values and they can be used in parallel with the values obtained by others. From the values transformed in this manner, and from those of VÄISÄLÄ and of KITAOKA, the average radiation error has been calculated for the different radiosonde

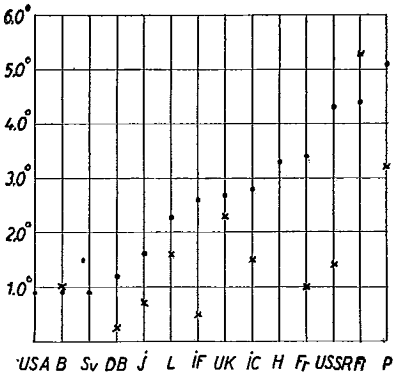


Fig. 6. The radiation error of different radiosondes at Payerne(·) (100 mb) and in laboratory tests (×).

types for 100, 70 and 50 mb pressure (Table 4). Although in these values decisive weight has been given to KITAOKA's and VÄISÄLÄ's results, I am inclined to consider these figures as representing the actual radiation error values at the Payerne comparison in 1956. However, since the observational material is relatively small in extent, the accuracy of the radiation error figures is about ±0.5°C.

The lower part of Table 4 contains the values of the radiation error employed with some radiosonde types. They afford an opportunity to study the degree to which the Payerne results agree with them. The results obtained with the Finnish and British radiosondes are of more or less equal magnitude with the calculated radiation errors. On the other hand, the calculated radiation error appears to be too small with the Japanese and slightly too high with the French radiosonde.

Comparison of the results of the laboratory investigation and the Payerne results (Table 4) shows that the results obtained in the laboratory with the Lang radiosonde used in Eastern Germany, and with the French, Russian, Japanese and Indian fan-type sondes differ most from the Payerne results. Since all these instruments have a radiation shield made of cardboard, the results seem to indicate that this may, in one way or another, affect the results obtained in the laboratory. A more detailed investigation of these circumstances was not within the scope of this investigation.

Considering the accuracy of the Payerne results and the fact that in the laboratory investigation only one radiosonde of each type was used, which may have differed from the average in regard to its radiation error characteristics, it is still possible to conclude that values of the radiation error showing fairly good agreement are obtained with numerous different radiosonde types both in the laboratory and in nature. Laboratory investigations can therefore be said to furnish a firm basis for the investigation of the radiation error and for the development of various methods intended to eliminate this error from the temperature observations made with radiosondes.

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