TABLE 4.—*Average duration of rains beginning in the hours indicated for the 25 years 1910–34, at St. Joseph, Mo.*

Month	A. M.												P. M.												
	12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	Mean
	H. m.	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*	*H. m.*
April	4 36	4 00	6 03	3 09	8 13	2 42	3 52	4 48	3 36	3 58	6 56	2 22	4 43	2 48	1 39	4 24	2 36	2 51	3 35	4 03	5 46	8 49	5 24	6 17	4 28
May	5 51	3 04	2 06	5 19	3 35	5 27	2 19	3 00	4 05	4 22	2 08	4 23	1 21	3 41	3 12	3 52	2 58	1 37	1 08	4 54	4 30	7 05	4 51	1 50	3 37
June	2 00	3 49	2 25	2 31	3 04	1 57	2 07	1 58	1 37	2 44	2 07	1 38	2 59	2 16	2 31	2 55	2 48	2 48	1 34	2 56	3 1[illegible]	6 15	[illegible] 44	3 19	2 41
July	4 34	3 03	3 11	1 48	1 54	2 28	2 07	1 26	1 25	0 54	1 31	1 07	1 21	0 52	2 28	1 26	0 49	2 10	1 11	2 11	2 38	2 18	2 40	4 37	2 05
August	4 33	4 02	2 23	4 16	3 18	2 07	2 37	2 16	1 37	2 13	1 53	1 59	2 08	1 17	1 54	1 10	3 47	1 17	3 52	5 19	4 24	3 02	4 36	4 12	2 56
September	5 43	5 59	2 22	3 45	1 42	2 29	2 20	4 19	3 04	2 40	4 25	2 43	1 49	2 39	1 53	1 54	3 40	2 29	4 44	2 58	5 40	8 14	4 56	6 10	3 42
October	5 50	3 36	4 44	4 57	4 25	1 59	4 16	4 59	2 15	4 07	3 27	3 25	5 03	3 28	6 06	1 13	2 59	4 09	2 20	3 37	3 28	5 11	5 39	3 34	3 57
Average	4 44	3 56	3 19	3 41	3 44	2 44	2 48	3 15	2 31	3 00	3 12	2 31	2 46	2 26	2 49	2 25	2 48	2 29	2 38	3 43	4 14	5 51	4 24	4 17	3 21

TABLE 5.—*Average duration of rainfall at St. Joseph, Mo., beginning between 7 p. m. and 7 a. m. and 7 a. m. and 7 p. m., April to October, 1910 to 1934 inclusive*

Month	7 p. m. to 7 a. m.	7 a. m. to 7 p. m.	Month	7 p. m. to 7 a. m.	7 a. m. to 7 p. m.
	H. m.	*H. m.*		*H. m.*	*H. m.*
April	5 14	3 41	September	4 22	3 02
May	4 14	2 59	October	4 16	3 38
June	3 02	2 20			
July	2 47	1 23	Averages	3 57	2 44
August	3 44	2 07			

HEATERS TO PREVENT FROSTING OF THEODOLITE LENSES AT LOW TEMPERATURES

By G. GRIMMINGER

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When pilot-balloon observations were begun at Little America, Antarctica, in 1934, it was soon found that the formation of frost on the theodolite lenses was going to cause considerable trouble. The frost formation became noticeable at a temperature of about −20° F., increasing in intensity with decreasing temperature. It was due to condensation, on the cold glass, of vapor in the observer's breath and of moisture evaporated from his face, and formed on both the eyepiece and the object lenses.[1] At the beginning of the winter night, with the advent of low temperatures and the use of lanterns, this formation of frost would after several minutes make it impossible to see the lantern attached to the balloon; and the observer would then have to stop observing and scrape the two lenses with a small piece of wood once or twice a minute; this, of course, made it difficult to keep the lantern in the field, and in some cases was responsible for losing the balloon entirely. This same difficulty was also experienced by Sverdrup on the *Maud* Expedition.[2]

To remedy the trouble, two simple but effective heaters were devised. The objective heater consisted simply of a 15-watt electric light bulb. This bulb was placed under the theodolite barrel, with the end of the bulb flush with the object lens; around the bulb and theodolite barrel was then wrapped a single layer of asbestos-covered wire mesh, and around this was wrapped a number of turns or ordinary friction tape. The asbestos-covered wire mesh prevented the bulb from burning the tape, and the tape kept the bulb securely fastened to the barrel of the theodolite and at the same time completely protected it from drift and snow. Leads were run from the bulb socket to our building nearby and tapped into a 110-volt line, the current for which was supplied by a gasoline generator. The heat from the lighted bulb heated the end of the theodolite barrel near the objective, and this in turn heated the lens by conduction, preventing any frost formation whatsoever.

This type of device was too bulky for the eyepiece and would not give the observer an unobstructed view of the theodolite scales; hence a resistance type of heater was used here. It consisted of a piece about three-fourths of an inch long cut from a larger resistance unit found among the electrical equipment and made of resistance wire wound on a ceramic tube. With a little filing of the inside of the tube it was easily made to slip on over the end of the eyepiece with a snug fit after the aperture disk had been removed. Leads were run from this resistor into the building where they were connected to a 6-volt storage battery. Although the ceramic tube was an insulator, it was quite thin and plenty of heat got through it to heat the eye-piece tube which in turn conducted heat to the lens. Although no note was made of the size and number of turns of wire used, the resistance was probably about four ohms. The storage battery was used to operate the timing device and theodolite lighting system as well as the eyepiece heater and had to be charged only two or three times during the year.

Although they were rather crude makeshift affairs, both of these heating devices proved very effective, and no frosting of the lenses was experienced after they were put into use. In cases where a 110-volt current is not available, a resistance heater could also be devised for the object lens and operated with a storage battery.

Experience also proved that a long eyepiece tube was much better than a short one. A small-size type of theodolite which was used for several days was quite unsatisfactory because the shortness of the eyepiece tube brought the observer's face and breath so close to the theodolite scales that they frosted over and became difficult to read after a short time.

[1] Scientific results of the *Maud* Expedition, Vol. 2, Meteorology, Part 1, Discussion by H. U. Sverdrup, p. 41.
[2] Ibid., p. 41.