

RATES OF BOX AND POCKET CHRONOMETERS

ON TRIAL

FOR PURCHASE BY THE BOARD OF ADMIRALTY,

AT THE

ROYAL OBSERVATORY, GREENWICH,

FROM 1907 JUNE 15 TO 1908 JANUARY 4.

NAME OF MAKER.	No.	Whether Swiss Days.	(1.) WEEKLY RATES															
			June 15-22	June 22-29	June 29 to July 6	July 6-13	July 13-20	July 20-27	July 27 to Aug 3	Aug. 3-10	Aug. 10-17	Aug. 17-24	Aug. 24-31	Aug. 31 to Sept. 7	Sept. 7-14	Sept. 14-21	NAME OF MAKER.	No.
			June 15-22	June 22-29	June 29 to July 6	July 6-13	July 13-20	July 20-27	July 27 to Aug 3	Aug. 3-10	Aug. 10-17	Aug. 17-24	Aug. 24-31	Aug. 31 to Sept. 7	Sept. 7-14	Sept. 14-21		
Johannsen	6160	2	+ 0.9	+ 2.8	+ 1.1	+ 0.7	- 1.9	+ 1.2	+ 1.0	- 1.3	- 1.5	+ 2.7	+ 2.9	+ 6.3	+ 4.8	+ 2.0	Johannsen	6160
Kullberg	7329	2	- 1.6	- 1.7	- 2.1	- 3.6	- 4.2	- 5.1	- 4.2	- 3.2	- 1.2	+ 1.8	+ 0.8	+ 1.2	- 3.2	- 4.0	Kullberg	7329
Johannsen	6147	2	- 4.7	- 4.8	- 5.2	- 7.0	- 8.0	- 7.8	- 4.5	- 4.5	- 0.6	+ 2.9	+ 4.6	+ 5.7	+ 6.6	+ 4.7	Johannsen	6147
Webb	5686	2	+ 4.0	+ 6.2	+ 7.5	+ 8.0	+ 7.3	+ 8.6	+ 10.5	+ 11.7	+ 9.3	+ 10.0	+ 16.8	+ 19.0	+ 14.3	+ 14.8	Webb	5686
Usher & Cole	2020	2	- 30.0	- 32.0	- 31.0	- 29.8	- 28.0	- 28.1	- 20.7	- 22.2	- 18.9	- 19.0	- 17.6	- 18.1	- 17.4	- 17.8	Usher & Cole	2020
Smalley	3708	2	- 3.9	- 2.8	- 5.7	- 4.5	- 3.1	- 4.3	- 4.7	- 4.5	- 13.6	- 13.5	- 8.7	- 5.6	- 3.4	- 6.6	Smalley	3708
Lindqvist	111	2	+ 7.0	+ 6.0	+ 5.9	+ 5.8	+ 3.8	+ 4.4	+ 6.6	+ 3.2	+ 1.8	+ 5.4	+ 12.0	+ 14.5	+ 11.4	- 1.0	Lindqvist	111
M. F. Dent	32074	2	+ 2.2	+ 1.6	+ 1.8	- 0.8	- 1.7	- 3.9	- 1.3	- 0.1	+ 3.0	+ 3.1	+ 2.8	+ 3.3	- 1.7	- 2.4	M. F. Dent	32074
Johannsen	6128	2	- 2.4	- 5.4	- 5.8	- 5.4	- 2.7	+ 0.2	+ 4.1	+ 5.9	+ 5.2	+ 9.8	+ 13.5	+ 11.5	+ 11.3	+ 7.5	Johannsen	6128
Webb	5683	2	+ 15.1	+ 18.0	+ 18.1	+ 19.2	+ 17.2	+ 18.0	+ 20.2	+ 17.1	+ 14.4	+ 16.2	+ 23.4	+ 27.4	+ 23.8	+ 29.0	Webb	5683
Kullberg	7513	2	- 3.8	- 3.4	- 3.4	- 3.1	- 2.1	- 3.1	- 3.8	- 1.6	+ 0.5	+ 7.1	+ 9.8	- 5.2	- 2.6	- 2.1	Kullberg	7513
Webb	5694	2	+ 38.3	+ 38.1	+ 38.3	+ 39.9	+ 37.9	+ 38.0	+ 40.1	+ 37.3	+ 40.7	+ 47.8	+ 50.6	+ 41.1	+ 40.5	+ 40.7	Webb	5694
Johannsen	6199	2	+ 1.4	+ 0.4	+ 2.5	+ 3.5	+ 2.7	+ 2.4	+ 4.9	+ 9.6	+ 10.5	+ 7.2	+ 18.0	+ 15.4	+ 11.6	+ 9.5	Johannsen	6199
Johannsen	6182	2	- 7.7	- 9.5	- 8.7	- 6.1	- 1.9	- 0.8	+ 1.5	+ 1.4	+ 2.7	+ 1.2	+ 1.2	+ 0.3	+ 0.2	+ 2.0	Johannsen	6182
Lindqvist	106	2	- 3.9	- 3.8	- 3.1	- 2.1	- 2.0	- 1.5	+ 0.5	+ 8.0	+ 8.0	+ 16.2	+ 19.7	+ 9.3	+ 9.6	+ 8.6	Lindqvist	106
Chronometrical Thermometer			- 455.8	- 386.9	- 381.4	- 380.7	- 179.3	- 672.2	- 742.2	- 2455.5	- 3349.1	- 3359.2	- 2458.6	- 688.8	- 712.1	- 545.0	Chronometrical Thermometer	
Mean Weekly Temperature			63.6	63.0	61.8	62.7	66.5	65.4	66.4	83.8	99.9	96.3	84.1	64.4	65.9	64.0	Mean Weekly Temperature	
Extremes of Temperature as shown by the Self-Registering Thermometers			62.7 64.6	60.6 65.0	60.3 67.9	61.2 64.9	64.8 68.0	64.3 67.3	80.7 90.2	93.1 103.9	89.0 106.2	69.0 92.0	61.3 67.0	63.5 66.9	63.0 65.0		Extremes of Temperature as shown by the Self-Register- ing Thermometers	

The sign + indicates that the rate is gaining.

+ During these weeks the Chronometers were placed in the chamber of an oven heated by jets of gas, the temperature being regulated by Kullberg's automatic governor which controls the supply of gas. The gas flames are exterior to the chamber, into which none of the injurious products of combustion can enter.

The Chronometrical Thermometer differs from an ordinary Chronometer in the construction of the balance only, the position of the metals forming the compensating rims being reversed. By this arrangement the effect of temperature is much magnified.

IN ORDER OF TIME.															NAME OF MAKER.	No.
Sept. 21-28	Sept. 28 to Oct. 5	Oct. 5-12	Oct. 12-19	Oct. 19-26 †	Oct. 26 to Nov. 2 †	Nov. 2-9 †	Nov. 9-16 †	Nov. 16-23	Nov. 23-30	Nov. 30 to Dec. 7	Dec. 7-14	Dec. 14-21	Dec. 21-28	Dec. 28 to Jan. 4		
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°		
+ 1.4	+ 4.5	+ 5.2	+ 7.1	+ 1.6	+ 3.0	+ 6.4	+ 10.8	+ 10.4	+ 9.4	+ 6.2	+ 2.0	- 1.3	- 3.3	- 2.6	Johannsen	6160
- 5.9	- 7.0	- 9.2	- 8.5	- 6.8	- 7.5	- 5.1	- 4.0	- 8.9	- 11.9	- 13.3	- 14.0	- 14.6	- 15.2	- 15.6	Kullberg	7329
+ 4.4	+ 1.9	- 2.3	- 4.9	- 1.8	+ 2.9	+ 6.3	+ 8.7	+ 7.4	+ 8.0	+ 4.9	+ 3.0	+ 1.5	- 2.2	+ 4.0	Johannsen	6147
+ 14.9	+ 15.6	+ 15.7	+ 17.8	+ 17.0	+ 15.2	+ 13.2	+ 19.7	+ 21.8	+ 22.1	+ 22.0	+ 19.9	+ 20.6	+ 21.7		Webb	5686
- 18.6	- 17.6	- 20.6	- 21.0	- 15.4	- 14.8	- 13.4	- 18.4	- 26.2	- 25.2	- 25.9	- 25.0	- 25.8	- 27.2	- 29.8	Usher & Cole	2020
- 5.0	- 5.3	- 7.7	- 7.0	- 6.8	- 11.0	- 12.5	- 8.7	- 9.8	- 11.4	- 10.7	- 13.1	- 11.8	- 15.1	- 18.8	Smalley	3708
+ 10.6	+ 8.6	+ 3.5	+ 3.2	+ 3.8	+ 1.3	+ 0.9	+ 3.8	+ 7.0	+ 5.4	+ 3.7	+ 1.9	- 3.1	- 1.7	- 7.1	Lindqvist	111
- 1.0	- 0.0	- 0.9	- 1.1	- 11.1	- 2.9	+ 3.7	- 5.7	- 2.1	+ 0.9	+ 3.4	- 3.8	- 0.5	- 0.8	- 4.2	M. F. Dent	32074
+ 4.9	+ 6.4	+ 5.0	+ 3.0	+ 9.4	+ 12.4	+ 13.3	+ 15.3	+ 8.7	+ 14.8	+ 13.9	+ 6.5	+ 6.2	+ 3.0	+ 2.1	Johannsen	6128
+ 27.6	+ 26.4	+ 25.3	+ 26.7	+ 25.0	+ 26.1	+ 18.1	+ 23.4	+ 26.4	+ 27.9	+ 29.3	+ 30.3	+ 31.8	+ 33.7	+ 34.8	Webb	5683
- 3.4	- 6.6	- 10.4	- 11.0	- 3.3	+ 0.5	+ 3.3	+ 2.6	- 5.1	- 9.2	- 10.8	- 11.5	- 11.6	- 10.9	- 11.4	Kullberg	7513
+ 40.7	+ 42.7	+ 42.1	+ 44.8	+ 44.9	+ 50.5	+ 54.2	+ 55.5	+ 55.8	+ 53.9	+ 51.9	+ 49.0	+ 50.9	+ 49.9	+ 49.2	Webb	5694
+ 8.7	+ 5.0	+ 5.5	+ 4.1	+ 6.8	+ 10.5	+ 6.6	+ 7.6	+ 13.6	+ 10.9	+ 7.9	+ 5.7	+ 3.0	+ 0.2	+ 0.8	Johannsen	6199
+ 4.5	+ 7.4	+ 7.1	+ 9.9	+ 8.1	+ 7.1	+ 8.1	+ 7.7	+ 4.1	+ 3.2	- 1.8	- 5.2	- 10.0	- 16.3	- 21.8	Johannsen	6182
+ 7.9	+ 7.0	+ 5.8	+ 6.1	+ 15.4	+ 23.2	+ 23.4	+ 22.0	+ 15.1	+ 16.1	+ 13.5	+ 12.3	+ 10.0	+ 9.8	+ 16.1	Lindqvist	106
- 547.0	- 552.8	- 516.1	- 184.8	- 1913.6	- 3322.9	- 3368.2	- 1644.4	+ 112.1	+ 109.0	+ 242.9	+ 122.8	+ 119.5	+ 134.0	+ 513.0	Chronometrical Thermometer	
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	Chronometrical Thermometer	
63.9	63.9	60.9	59.7	78.0	92.2	94.2	73.4	54.5	53.5	59.1	54.8	53.4	53.3	49.9	Mean Weekly Temperature	
60.5	61.0	59.3	58.4	74.0	85.7	89.0	60.0	52.7	50.3	51.7	53.2	50.5	47.4	45.0	{ Extremes of Temperature as shown by the Self-Register- ing Thermometers.	
67.0	67.7	62.5	61.2	83.6	99.2	100.2	83.2	55.9	56.0	54.0	56.0	57.7	53.3	56.2		

The Chronometers are placed in order of merit, their respective positions being determined by consideration of the irregularities of rate exhibited in Table III.

Only those Chronometers have been included in this list for which δ did not exceed 12 seconds.

† During these weeks the Chronometers were placed in the chamber of an oven heated by jets of gas, the temperature being regulated by Kullberg's automatic governor which controls the supply of gas. The gas flames are exterior to the chamber, into which none of the injurious products of combustion can enter.

The Chronometers are placed in order of merit, their respective positions being determined by consideration of the irregularities of rate exhibited in Table III.

Only those Chronometers have been included in this list for which b did not exceed 12 seconds.

NAME OF MAKER.	No.	Whether for 3 Days	ADDRESS OF MAKER.	Construction of Escapement, Balance, and Spring, from the Description furnished by the Maker.	(III.) ABSTRACT OF		
					Least Weekly Sum.	Extremes of Temperature.	
Johannsen	6150	2	149, Minories, London, E.	Auxiliary to balance acting in heat; palladium spring.	- 3.8	47.4 - 58.3	
Kullberg	7329	2	105, Liverpool Road, London, N.	Kullberg's auxiliary balance; palladium spring.	- 15.8	45.0 - 56.2	
Johannsen	6147	2	149, Minories, London, E.	Auxiliary to balance acting in heat; palladium spring.	- 8.0	64.8 - 68.0	
Webb	5695	2	69, Charlton Road, Blackheath, S.E.	Auxiliary compensation; steel spring.	+ 4.0	62.7 - 64.6	
Usher & Cole	2020	2	339, St. John Street, London, E.C.	Auxiliary to balance acting in cold; palladium spring.	- 32.0	60.6 - 65.0	
Smalley	8708	2	69, Linton Street, London, N.	Smalley's auxiliary balance; palladium spring.	- 18.8	45.0 - 56.2	
Lindqvist	111	2	15, Alderney Street, Pimlico, W.	Kullberg's auxiliary balance; palladium spring.	- 7.1	45.0 - 56.2	
M. F. Dent	32074	2	34, Cookpur Street, London, S.W.	Auxiliary to balance acting in heat; palladium spring.	- 11.1	74.0 - 83.6	
Johannsen	6128	2	149, Minories, London, E.	Auxiliary to balance acting in heat; palladium spring.	- 5.8	60.3 - 67.9	
Webb	5698	2	69, Charlton Road, Blackheath, S.E.	Auxiliary compensation; steel spring.	+ 14.4	93.1 - 108.9	
Kullberg	7513	2	105, Liverpool Road, London, N.	Kullberg's auxiliary balance; palladium spring.	- 11.6	50.5 - 57.7	
Webb	5694	2	69, Charlton Road, Blackheath, S.E.	Auxiliary compensation; steel spring.	+ 37.3	80.7 - 90.2	
Johannsen	6199	2	149, Minories, London, E.	Auxiliary to balance acting in heat; palladium spring.	+ 0.2	47.4 - 58.3	
Johannsen	6182	2	149, Minories, London, E.	Auxiliary to balance acting in heat; palladium spring.	- 21.8	45.0 - 56.2	
Lindqvist	106	2	15, Alderney Street, Pimlico, W.	Kullberg's auxiliary balance; palladium spring.	- 3.9	62.7 - 64.6	

The sign + indicates that the rate is gaining.

THE PRINCIPAL CHANGES OF RATE DURING THE 29 WEEKS.

Mean Temperature.	Greatest Weekly Sum.	Extremes of Temperature.	Mean Temperature.	Difference between the Greatest and Least. (a)	Greatest Difference between one Week and the next. (b)	Mean Temperatures for these two Weeks.	Trial No. a + 2b.	NAME OF MAKER.	No.
53.3	+ 10.8	60.0 - 83.2	73.4	14.1	5.6	59.7 - 78.0	25.1	Johannsen	6150
49.9	+ 1.8	89.0 - 106.2	96.3	17.6	4.9	73.4 - 54.5	27.4	Kullberg	7329
66.5	+ 8.7	60.0 - 83.2	73.4	16.7	6.2	53.3 - 49.9	29.1	Johannsen	6147
63.6	+ 22.1	50.3 - 56.0	53.5	18.1	6.8	96.3 - 84.1	31.7	Webb	5695
68.0	- 13.4	89.0 - 100.2	94.2	18.6	7.8	73.4 - 54.5	34.2	Usher & Cole	2020
49.9	- 2.8	60.6 - 65.0	63.0	16.0	9.1	88.9 - 99.9	34.2	Smalley	8708
49.9	+ 14.5	63.5 - 66.9	65.3	21.6	6.6	84.1 - 64.4	34.8	Lindqvist	111
78.0	+ 3.7	89.0 - 100.2	94.2	14.8	10.0	59.7 - 78.0	34.8	M. F. Dent	32074
61.8	+ 15.3	60.0 - 83.2	73.4	21.1	7.4	53.1 - 54.8	35.9	Johannsen	6128
99.9	+ 34.8	45.0 - 56.2	49.9	20.4	8.0	92.2 - 94.2	36.4	Webb	5698
53.4	+ 9.8	69.0 - 92.0	84.1	21.4	7.8	64.4 - 65.3	37.0	Kullberg	7513
83.8	+ 55.8	52.7 - 55.9	54.5	18.5	9.5	64.4 - 65.3	37.5	Webb	5694
53.3	+ 18.0	69.0 - 92.0	84.1	17.8	10.8	96.3 - 84.1	39.4	Johannsen	6199
49.9	+ 8.1	{ 74.0 - 83.6 89.0 - 100.2 94.2 }	{ 78.0 94.2 94.2 }	29.9	6.3	84.1 - 53.3	42.5	Johannsen	6182
63.6	+ 23.4	89.0 - 100.2	94.2	27.3	9.3	59.7 - 78.0	45.9	Lindqvist	106

The Chronometers are placed in order of merit, their respective positions being determined by consideration of the irregularities of rate exhibited in the Table above. The Trial No. a + 2b is taken as a measure of the irregularities of rate.

Only those Chronometers have been included in this list for which it did not exceed 12 seconds.

(1) WEEKLY RATES IN ORDER OF TIME.

Order of Merit.	June 15—22		June 22—29		June 29 to July 6		July 6—13		July 13—20		July 20—27		July 27 to Aug. 3		Aug. 3—10		Aug. 10—17		Aug. 17—24		Aug. 24—31		Sept. 1 to Sept. 7		Sept. 7—14		Sept. 14—21		Sept. 21—28		Sept. 28 to Oct. 5		Oct. 5—12		Oct. 12—19		Oct. 19—26		Oct. 26—30		Oct. 30 to Nov. 2		Nov. 2—5		Nov. 5—9			
	Pocket Chronometer Horizontal. Dial up.																								Chron. Vertical Pendulum up. +	Chron. Vertical Pendulum right. +	Chron. Vertical Pendulum left. +	Chron. Vertical Pendulum up. +																				
1	+10.6	+18.0	+18.8	+19.4	+20.8	+19.8	+16.1	+13.8	+15.6	+14.0	+14.8	+17.2	+16.1	+10.9	+12.5	+15.1	+15.8	+15.0	-0.8	+15.8	+18.2	+25.9	+25.4																									
2	-2.0	-7.0	-2.7	-7.5	-6.6	-11.5	-3.0	+3.6	-6.5	-7.8	-7.2	-7.4	-16.3	-17.6	-17.7	-19.9	-24.2	-24.0	-28.3	-36.4	-31.0	+18.2	-29.4																									
3	+16.9	+15.4	+14.4	+17.6	+20.4	+19.6	+23.1	+23.0	+19.3	+20.8	+23.2	+19.4	+18.9	+22.1	+21.6	+22.8	+19.2	+22.5	+27.4	+2.6	+10.5	+13.5	+17.7																									
4	+26.6	+29.4	+32.9	+33.5	+38.8	+36.8	+41.1	+32.1	+23.8	+32.3	+37.0	+32.4	+30.9	+30.3	+31.4	+32.3	+31.2	+30.7	+15.1	+3.7	-4.2	-6.5	-21.7																									
5	+45.9	+47.9	+47.4	+48.9	+71.6	+74.1	+75.2	+73.9	+45.8	+41.3	+59.3	+65.2	+70.3	+72.6	+71.1	+74.4	+69.6	+68.5	+55.0	+17.9	+23.8	+26.1	+20.5																									
6	+4.4	+7.8	+7.9	+11.8	+14.1	+14.1	+16.1	+3.8	-3.6	-2.5	+1.2	+3.4	+5.9	+1.9	-1.0	+1.1	+1.4	+2.0	-14.2	+73.7	+51.3	+43.2	+31.9																									
7	+43.7	+41.6	+43.8	+46.0	+45.3	+45.0	+40.9	+67.7	+61.6	+51.3	+86.4	+80.6	+56.5	+82.0	+80.8	+74.1	+72.0	+72.5	+78.9	-20.0	-16.3	-20.6	-19.8																									
	68.6	68.0	61.8	62.7	66.5	65.4	66.4	83.8	96.9	96.3	84.1	64.4	60.3	64.0	65.9	65.9	60.9	56.7	86.5	94.8		86.3																										
	62.7	60.6	60.8	61.2	64.8	63.5	64.3	80.7	80.1	89.0	69.0	61.8	68.5	68.0	60.5	61.0	59.3	58.4	81.0	75.0		76.0																										
	64.6	65.0	67.9	64.9	68.0	67.3	68.6	90.2	108.9	106.2	92.0	67.0	66.9	65.0	67.0	67.7	62.5	61.2	89.8	89.0		89.0																										

† The weekly rates have been computed from the rates for four days. * The weekly rates have been computed from the rates for three days.
During the periods Aug. 3 to Aug. 31 and Oct. 19 to Nov. 16, the Pocket Chronometers were placed in the chamber of an oven heated by jets of gas, the temperature being regulated by Kullberg's automatic governor which controls the supply of gas. The gas flames are exterior to the chamber, into which none of the injurious products of combustion can enter.

(2) ABSTRACT OF PRINCIPAL CHANGES OF RATE.

Nov. 9-16	Nov. 16-23	Nov. 23-30	Nov. 30 to Dec. 7	Dec. 7-14	Dec. 14-21	Dec. 21-28	Dec. 28 to Jan. 4	Difference of Weekly Rates.					Trial Number.	NAME OF MAKER.	No.	ADDRESS OF MAKER.	
Pocket Chronometer. Horizontal. Dial up.								Difference between greatest and least Weekly Rate.			Greatest difference between any week and the next.						$a+2b$ $\frac{1}{2}(c+\frac{d+e}{2})$
								Pendant up —Dial up.	Pendant right —Dial up.	Pendant left —Dial up.							
a.	b.	c.	d.	e.													
+ 1.0	+ 8.1	+ 9.6	+10.4	+12.9	+12.2	+10.8	+10.0	21.1	15.3	+20.2	+17.8	+25.5	51.7	69.0	J. Player & Son.	38499	Butts Lane, Coventry.
- 9.2	- 0.1	-12.4	- 3.8	- 6.7	+ 3.1	- 9.1	- 2.5	22.9	12.3	-15.1	-13.2	+38.0	54.5	79.3	Lindqvist.....	109	13 Alderney Street, Fimlico, W.
+28.3	+ 8.1	+10.7	+12.1	+16.1	+15.1	+11.5	- 2.5	29.9	18.2	-16.7	-18.4	-13.4	66.8	79.6	Lindqvist.....	110	13 Alderney Street, Fimlico, W.
+14.1	+38.1	+34.1	+31.7	+32.3	+33.7	+49.7	+51.7	37.6	24.0	-23.6	-18.8	-21.1	85.6	104.1	Newsome & Co.	150708	14 and 15 The Butts, Coventry.
+47.0	+54.5	+53.1	+60.3	+57.7	+50.6	+55.6	+51.1	33.9	28.6	-31.8	-27.2	-24.9	91.1	115.7	Thorneloe.....	57048	13-17 Stanton Street, Coventry.
-11.3	-14.7	-14.8	-17.6	-14.8	-12.7	-19.3	-34.7	50.8	16.2	+65.6	+64.1	+56.0	83.2	138.0	J. Player & Son.	38498	Butts Lane, Coventry.
+90.1	+80.7	+68.3	+74.1	+72.4	+57.7	+61.3	+74.4	49.8	35.1	-104.2	-100.8	-105.3	120.0	206.5	Wales & McCulloch.	38995	20 Ludgate Hill, London, E.C.
85.2	54.5	55.5	55.1	54.8	53.4	53.8	49.9	Mean Weekly Temperature.									
81.2	52.7	50.3	51.7	53.2	50.5	47.4	45.0	Extremes of Temperature as shown by the Self-Registering Thermometers.					The sign + indicates a gaining rate.				
88.0	55.9	56.0	54.0	56.0	57.7	58.3	56.2										

The quantities a, b, c, d, e , in the formula $a + 2b + \frac{1}{2} \left(c + \frac{d+e}{2} \right)$ are taken numerically without regard to sign.

The sign + indicates a gaining rate.