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THE REGISTRATION OF EARTHQUAKES AT THE BERKELEY STATION

AND

AT THE LICK OBSERVATORY STATION

FROM

OCTOBER 1, 1919, TO MARCH 31, 1920

BY

LEWIS A. BOND

UNIVERSITY OF CALIFORNIA PRESS

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*Acknowledgment is made of the contribution of Mr. W. E. Inman, who measured and interpreted the seismograms of the Lick Observatory Station from October 1, to December 1, 1919, and those of the Berkeley Station from October 1 to December 15, 1919.

Symbols and Notation

1. *Character of the Earthquake*—

I. Perceptible. II. Moderately strong. III. Strong.

d (terrae motus domesticus)	Local shock (origin less than 100 kilometers distant).
v (terrae motus vicinus)	Near shock (origin from 100 to 1,000 kilometers distant).
r (terrae motus remotus)	Distant shock (origin from 1,000 to 5,000 kilometers distant).
u (terrae motus ultimus)	Very distant shock or teleseism (origin more than 5,000 kilometers distant).

2. *Phases of the Seismogram*—

P (undae primae)	First phase, or first preliminary tremors.
PR_n	Waves n-times reflected at the earth's surface.
S (undae secundae)	Second phase, or second preliminary tremors.
SR_n	Waves n-times reflected at the earth's surface.
PS	Waves changed from longitudinal to transverse oscillation, or vice versa, through reflection at the earth's surface.
L (undae longae)	Long waves, chief phase, or principal part.
M(undae maximae)	Greatest motion in the chief phase.
C (coda)	Tail or end portion.
F (finis)	End of discernible movement.

3. *Nature of the Motion*—

i (impetus)	Sudden beginning of the motion.
e (emersio)	Gradual beginning of the motion.
T (period)	Time of one complete oscillation.
A	Amplitude of the motion, measured from the median line in microns (μ=1/1000 mm.).
A_E	E-W component of A.
A_N	N-S component of A.
A_V	Vertical component of A.

4. *Time*—

O (origin)	Time of shock at point of origin.

THE BERKELEY STATION

CONSTANTS

Latitude and longitude of the center of the seismographic room:

ϕ = 37° 52′ 15.″9 N. Lat.

λ = 122° 15′ 36.″6 W. from Greenwich.

Time. All determinations are reduced to Greenwich mean civil time.

Altitude, 85.4 meters (280 feet) above mean sea-level.

Constants of the Seismographs

	Period	Magnif.	Damping
Bosch-Omori Seismograph N-S component	15s	80	8–1
Bosch-Omori Seismograph E-W component	15s	80	8–1
Wiechert Seismograph Vert. component	6s	80	8–1
Omori Tromometer N-S component	2s	60	.....
Omori Tromometer E-W component	2.5s	60	.....
Marvin Strong-motion Seismograph—			
E-W component	6.5s	5.8	1.3–1
N-S component	6.5s	5.1	1.4–1

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A$_E$	Amplitude A$_N$	Amplitude A$_V$	Remarks
	1919			h m s	s	μ	μ	μ	
1	1 Oct.	I_r(?)	e$_N$	19 35 59					Trace of a distant shock on all components.
			e$_E$	19 36 06					
			e$_V$	19 36 09					
			M_N	19 37 09	11				
			F	19 45 53					
2	3 Oct.	I_r(?)	e	10 11±					Trace of a distant earthquake on all components. Very gradual beginning. Waves of even amplitude.
			F	10 36±					
3	5 Oct.	I_v	e P_N	2 39 22					No definite maximum. Phases doubtful. Registered by both components of the Omori tromometer.
			e P_E	2 39 23					
			i P_V	2 39 23					
			L_N	2 40 37					
			L_E	2 40 26					
			L_V	2 40 26					
			F	2 52±					
4	8 Oct.	I?	e	5 23±					Flat waves. Trace of a distant shock.
			F	5 36±					
5	10 Oct.	I_d	e P_E	1 10 15.5					*Trace amplitude. P doubtful because of microseisms. Δ=760–880 km.
			e P_N	1 10 02.3					
			e P_V	1 10 09.7					
			L_E	1 12 22.5					
			L_N	1 12 08.1					
			L_V	1 11 59.1					
			M_{1E}	1 12 49	9	2000	*		
			M_{1N}	1 12 15	8		3200	*	
			M_{2E}	1 14 14	7	2600	*		
			M_{2N}	1 12 57	8		3800	*	
			M_{3N}	1 18 25	7		4200	*	
			M_{3E}	1 19 16	3	1300	*		
			C	1 25±					
			F	2 36±					
6	18 Oct.	I_d	*O*	*15 31 12.4*					Δ=98 km. Pen trace on N-S shows side shift 1.3^s before rapid vibrations of first preliminary tremors begin. Registered on Omori tromometer.
			c P_N	15 31 26.3					
			ı P_E	15 31 26.4					
			ı P_N	15 31 27.2					
			M_E	15 31 27.9	½	12.5			
			i L_N	15 31 39.4					
			i L_E	15 31 39.2					
			ı LM_V	15 31 40.4	½			3.7	
			M_N	15 31 40.5	½		12.5		
			F	15 33±					
7	18 Oct.	I_d	*O*	*18 28 48*					After shock of No. 6. Main phase consists of rapid, irregular vibrations.
			i P_N	18 29 01.5					
			i P_E	18 29 02.2					
			i P_V	18 29 01.4					
			i LM_N	18 29 15.3	½		3.7		
			i L_E	18 29 14.5					
			i LM_V	18 29 14.8					
			F	18 30 04					
8	20 Oct.	I_r	e P_N	15 27 06					Trace of a distant shock.
			e L_N(?)	15 29 22					
			F	15 40±					
9	23 Oct.	I_d	i P_N	1 56 27.3					Trace of a nearby shock. Rapid pen strokes on all components.
			i P_E	1 56 27.0					
			e P_V	1 56 27					
			M_N	1 56 28.5	<½		7.5		
			M_E	1 56 28.3	<½	6.2			
			F	1 57 19					
10	26 Oct.	I_d	e P	22 39 15					Recorded by vertical component only. Markers out of order on other instruments.
			F	22 39 40					
11	1 Nov.	I_r(?)	e	5 49±					Barely perceptible long flat waves on all components.
			F	5 53±					
12	10 Nov.	I_d	i P_E	18 51 21.3					Δ=27.3 km. Main phase consists of irregular vibrations of ½^s period.
			i P_N	18 51 21.3					
			i P_V	18 51 20.9					
			L_E	18 51 24.1					
			L_N	18 51 24					
			L_V	18 51 24.7					
			C	18 51 30					
			F	18 51 52					
13	18 Nov.	$I_{(r)}$?	e P_N	22 44 02					Long flat waves with microseisms superimposed. No record on V.
			e P_E	22 41 43					
			F	23 01±					
14	19 Nov.	I_d	*O*	*19 26 01*					Δ=620 km. No definite maximum. Phases somewhat obscured by microseisms.
			e P_N	19 27 20					
			e P_E	19 27 27					
			e P_V	19 27 27					
			L_N	19 28 56					
			L_E	19 28 54					
			L_V	19 28 56					
			F	19 41±					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A$_E$	Amplitude A$_N$	Amplitude A$_V$	Remarks
	1919			h m s	s	μ	μ	μ	
15	20 Nov.	I_d	*O*	*14 23 06.9*					Δ=281 km.
			i P_E	14 23 47.8					
			e P_N	14 23 48.3					
			i P_V	14 23 49.0					
			L_E	14 23 31					
			L_N	14 24 30					
			i L_V	14 24 26					
			M_V	14 24 34	3			10	
			F	14 28±					
16	20 Nov.	I_r	*O*	*14 25 56*					Δ=4630 km.
			e P_E	14 33 58					
			e P_N	14 33 58					
			e P_V	14 33 55					
			e S_N	14 39 48					
			L_E	14 46 15					
			L_N	14 46 09					
			F	15 11±					
17	21 Nov.	I_d	e P_N	20 09 05					Weak focal shock. Registered on Omori tromometer.
			e P_E	20 09 05					
			e P_V	20 09 04					
			LM_N	20 09 06	½		6		
			C	20 09 13					
			F	20 10 14					
18	22 Nov.	I_d	e P_N	23 50 57.0					Weak focal shock. Phases poorly defined. Registered on Omori tromometer.
			e P_E	23 50 57.1					
			e P_V	23 50 57.3					
			L_N	23 50 59.4					
			L_E	23 50 59.4					
			L_V	23 50 59.5					
			F	23 51 34					
19	25 Nov.	II_d	*O*	*11 03 05.7*					Δ=98 km.
			i P	11 03 19.3					Started Marvin strong motion seismograph.
			i L	11 03 32					
			M_N	11 03 32.4	<½		30		
			M_E	11 03 32.8	1.6	24			
			M_V	11 03 33	0.8			21	
			F	11 10 21					
20	5 Dec.	I_d	i P_E	10 39 20					Rapid vibrations.
			i P_N	10 39 18					
			i P_V	10 39 20					
			L	10 39 23					
			F	10 40 16					
21	11 Dec.	I_d	e P_{EN}	23 26 41					Strong thickening of pen trace.
			L	23 26 52					
			F	23 27 20					
22	14 Dec.	$I_{(r)}$?	e	1 50 56					Trace of a distant quake.
			L?	1 58 41					
			F	2 10±					

No.	Date	Charac.	Phase	Time G. M. C. T.		Amplitude A$_E$	Amplitude A$_N$	Amplitude A$_V$	Remarks
	1919			h m s	s	μ	μ	μ	
23	19 Dec.	I_v	*O*	*13 58 13*					Δ=234 km.
			e P_N	13 58 50					Not registered on V.
			e P_E	13 58 48					
			e L_N	13 59 21					
			e L_E	13 59 23					
			M_N	13 59 28	1.6		10		
			M_E	13 59 27	1.5	6			
			F	14 03 21					
	1920								
24	1 Jan.	I_v	*O*	*2 34 47*					Δ=546 km.
			e P_{NV}	2 36 13					No definite maximum. Main phase consists of irregular waves of amplitude 2.5μ and period 3ˢ. Reported felt at San Diego.
			e S_N	2 37 14					
			e L_N	2 37 36					
			e L_V	2 37 32					
			F	2 42 04					
25	2 Jan.	I_v	*O*	*13 18 04*					Δ=7 35 km
			e P	13 19 43					Sinusoidal waves of main phase on N-S have superimposed vibrations of ½ˢ period.
			e L	13 21 30					
			M_N	13 24 36	7		10		
			M_E	13 23 08	9	7			
26	4 Jan.	III_r	*O*	*4 22 04*					Δ=3170 km.
			e P_N	4 28 18					Mexico. See discussion in text.
			e P_E	4 28 22					
			e P_V	4 28 16					
			e S_N	4 33 13					
			e S_E	4 33 11					
			e L_N	4 36 02					
			M_N	4 41 59	14		101		
			M_E	4 41 52	10	132			
			M_V	4 41 41	10			53	
			F	5 05±					
27	12 Jan.	$I_{(u)}$?	e	14 14 35					Trace of a distant quake on horizontal components only.
			F	14 54 35					
28	14 Jan.	$I_{(u)}$?	e	15 20 53					Trace of a distant quake. Not recorded on V.
			F	15 40 29					
29	21 Jan.	$I_{(r)}$?	e	6 25 03					Trace of a distant quake on horizontal components only.
			F	6 27±					
30	23 Jan.	$I_{(v)}$?	e	1 11 07					Irregular waves with average period of 6ˢ and maximum amplitude of 4μ. See Lick Observatory Station, No. 47.
			F	1 13 44					
31	30 Jan.	$I_{(r)}$?	e	18 51 15					Trace of a distant quake on all components.
			F	19 01 38					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AV	Remarks
	1920			h m s	s	μ	μ	μ	
32	2 Feb.	III_u	*O*	*11 22 17*					Δ=9770 km. Centered in province of Minas Geraes, Brazil. See discussion in text.
			e P_V	11 35 08					
			e P_E	11 35 17					
			e P_N	11 35 19					
			e S_E	11 46 15					
			e S_N	11 45 53					
			e S_V	11 46 46					
			e L_E	12 04 38					
			e L_V	12 04 32					
			M_E	12 08 31	22	130			
			M_N	12 41 41	16		15		
			M_V	12 08 15	22			130	
			C	14 04 30					
			F	14 29±					
33	5 Feb.	I_v	*O*	*9 09 10*					Δ=330 km.
			i P_N	9 09 56					
			i P_E	9 10 05					
			i P_V	9 09 57					
			e S_E	9 10 32					
			e S_N	9 10 40					
			e S_V	9 10 34					
			i L_{NV}	9 10 40					
			i L_E	9 10 44					
			M_N	9 10 41	3		8		
			M_E	9 10 45	2	5			
			M_V	9 10 42	1			6	
			C	9 12 27					
			F	9 15±					
34	7 Feb.	$I_{(r)}$?	e	12 24 19					Trace of a distant quake on all components.
			F	12 30 53					
35	10 Feb.	$I_{(r)}$?	e	9 51 46					Trace of a distant quake on all components.
			F	10 25 34					
36	10 Feb.	I_u	*O*	*22 06 39*					Δ=6170 km.
			e P_E	22 16 24					
			e P_N	22 16 22					
			e P_V	22 16 20					
			e PS_E	22 23 37					
			e S_E(?)	22 26 12					
			e L_N	22 33 42					
			M_E	22 44 03	14	28			
			M_N	22 39 52	15		35		
			M_V	22 41 20	15			17	
			F	23 54±					
37	14 Feb.	I_v	e P_N	20 45 40					Time of beginning of main phase is doubtful.
			e P_V	20 45 38					
			e L_N	20 45 59					
			e L_V	20 46 34					
			M_N	20 47 37	8		2		
			M_E	20 48 55	9	6			
			F	21 02±					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AV	Remarks
	1920			h m s	s	μ	μ	μ	
38	22 Feb.	I_r	*O*	*17 39 56*					Δ=3317 km. No well defined maximum on V. Incidence of S not determinable.
			i P_N	17 45 49					
			e P_E	17 45 48					
			e P_V	17 45 48					
			e L_N	17 54 00					
			e L_E	17 53 55					
			M_N	17 54 04	11		3		
			M_E	17 54 05	11	4			
			F	18 09±					
39	28 Feb.	$I_{(r)}$?	e	19 15 19					Trace of a distant quake on horizontal components.
			F	19 23 49					
40	12 Mar.	$I_{(r)}$?	e	18 11 33					Not recorded on V. e and F obscured by micros.
			F	18 31±					
41	15 Mar.	$I_{(r)}$?	e	12 39 24					Sinusoidal waves, slightly irregular. Trace of the main phase of a distant quake, on all components.
			F	13 04					
42	20 Mar.	II_v	*O*	*17 48 43*					Δ=245 km. Registered by the Omori tromometer.
			e P	17 49 19					
			e S_{EV}	17 49 47					
			e S_N	17 49 46					
			e L_V	17 49 52					
			e L_{EN}	17 49 53					
			M_V	17 51 20	5			59	
			M_N	17 50 53	10		101		
			M_E	17 51 12	11	129			
			F	18 13±					
43	20 Mar.	$I_{(u)}$?	e	18 43 01					Record of a very distant quake. Irregularities of the record are complicated by microseisms, and the phases are quite indeterminable.
			F	20 08±					
44	22 Mar.	$I_{(r)}$?	e	20 35 39					Trace of a distant quake on horizontal components only.
			F	21 01±					
45	23 Mar.	$I_{(r)}$?	e	15 39 45					Trace of a distant quake on all components.
			F	15 53					
46	29 Mar.	II_r	*O*	*5 08 25*					Δ=1260 km. No change in character which could be reasonably assigned to the arrival of *S* waves could be detected.
			e P_{VN}	5 11 09					
			e P_E	5 11 15					
			e L_{VE}	5 13 57					
			e L_N	5 14 04					
			M_E	5 17 17	13	80			
			M_N	5 16 45	10		87		
			M_V	5 17 17	9			38	
			F	6 26					

THE LICK OBSERVATORY STATION

CONSTANTS

Constants of the Station

Latitude and longitude of the center of the seismographic room:

$\phi = 37° 20' 24.''5$ N. Lat.
$\lambda = 121° 38' 34''$ W. from Greenwich.

Time. All determinations are reduced to Greenwich mean civil time.

Altitude, 1281.7 meters (4202.25 feet) above mean sea-level.

Constants of the Seismographs

	Period	Magnif.	Damping
Wiechert Seismograph N-S component	8.0	80	4:1
Wiechert Seismograph E-W component	7.0	80	5:1
Wiechert Seismograph Vertical component	2.5	80	2:1

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A$_E$	Amplitude A$_N$	Amplitude A$_V$	Remarks
	1919			h m s	s	μ	μ	μ	
1	3 Oct.	$I_{(r)}$?	e	10 14 06					Distant shock recorded by N-S component only. See Berkeley Station, No. 2.
			F	10 26 36					
2	5 Oct.	I_d	e P_{EN}	2 40 54					Irregular vibrations of small amplitude on horizontal components only.
			F	2 45 00					
3	8 Oct.	I_d	i P_{EN}	3 34 39.5					Strong thickening of pen trace on horizontal components. Sudden increase in amplitude with beginning of *L* phase. No maximum on vertical component.
			i P_V	3 34 39.9					
			i LM_{NE}	3 34 41.4		7.5	8.7		
			L_V	3 34 41.6					
			F	3 34 52					
4	10 Oct.	$I_{(r)}$?	e	1 10 08					Not recorded on *V*.
			F	1 11 29					
5	11 Oct.	I_d	e	22 56 07					Thickening of pen trace.
			F	22 56 08					
6	13 Oct.	I_d	e	20 35 54					Thickening of pen trace.
			F	20 36 10					
7	13 Oct.	I_d	i P_E	22 57 57.2					Focal shock recorded on all components.
			i P_N	22 57 56.6					
			i L_E	22 57 59.6					
			i LM_{NV}	22 57 59.7			8	6	
			F	22 58 03					
8	18 Oct.	III_d	*O*	*15 32 07.8*					Δ=32.8 km.
			i P_{EN}	15 32 12.3					First shift of ground east, south, and down.
			i P_V	15 32 12.5					
			i LM_{NE}	15 32 15.9	½	142	110		
			i LM_V	15 32 16.1	½			22	
			F	15 32 42					
9	18 Oct.	II_d	*O*	*18 29 43.2*					Δ=37.6 km.
			i P_{EN}	18 29 48.4					
			i P_V	18 29 47.4					
			i LM_{EN}	18 29 52.7		39	54		
			i L_V	18 29 52.1					
			F	18 31 05					
10	21 Oct.	$I_{(r)}$?	e	3 30 07					Trace of a distant quake. Not recorded on *V*.
			F	3 36±					
11	23 Oct.	I_d	i P_{EV}	0 08 05					Strong thickening of pen trace on all components.
			L	0 08 11					
			F	0 08 15					

No.	Date	Charac.	Phase	Time G. M. C. T.			Amplitude			Remarks
							A$_E$	A$_N$	A$_V$	
	1919			h	m	s	s	μ	μ	μ	
12	26 Oct.	$I_{(r)}$?	e	20	28	40				Long flat waves. Not recorded on *V*.
			F	20	34	23				
13	27 Oct.	$I_{(r)}$?	e	18	15	42				May not be seismic.
			F	18	17	49				
14	29 Oct.	I_d	i	1	06	22				No phases discernible.
			F	1	06	30				
15	29 Oct.	I_d	i	2	22	14				No phases discernible.
			F	2	22	21				
16	31 Oct.	I_d	i	16	22	19				Thickening of pen trace.
			F	16	22	27				
17	3 Nov.	I_d	i	22	52	46				Thickening of pen trace. Recorded on *V* as slight shift of trace.
			F	22	52	49				
18	3 Nov.	I_d	e	22	53	30				Thickening of pen trace. Shift of trace on *V*.
			F	22	53	37				
19	5 Nov.	I_d	i P	0	32	33				Thickening of pen trace.
			F	0	32	39				
20	5 Nov.	I_d	i	0	41	36				Thickening of pen trace on horizontal components.
			F	0	41	40				
21	13 Nov.	I_d	e P$_N$	20	49	28				Best record on N-S. Very rapid vibrations. No phases discernible on E-W and *V*.
			L$_N$	20	49	32				
			M$_N$	20	49	45			11	
			F	20	50	38				
22	18 Nov.	$I_{(v)}$?	e	22	47	06				Nor recorded on *V*.
			F	22	56	36				
23	19 Nov.	I_d	i	19	27	27				Vertical record illigible due to overscoring. Very irregular vibrations on horizontal components.
			F	19	27	56				
24	20 Nov.	I_d	e	14	24	32				Minute irregular vibrations recorded on E-W component only. N-S component out of order.
			F	14	25	55				
25	20 Nov.	I_v	e	14	35					See Berkeley Station No. 16.
			F	15	09					
26	20 Nov.	I_d	e P	22	38	32				*V* overscored. No maximum on E-W.
			L	22	38	48				
			M$_N$	22	38	48	$<\frac{1}{2}$		5	
			F	22	39	00				

No.	Date	Charac.	Phase	Time G. M. C. T.			Period	Amplitude			Remarks
								A$_E$	A$_N$	A$_V$	
	1919			h	m	s	s	μ	μ	μ	
27	21 Nov.	I_d	e	19	10	36					Thickening of pen trace on horizontal components. Abrupt shift of trace on *V*.
			F	19	10	44					
28	21 Nov.	I_d	i	19	37	15					Rapid pen strokes of small amplitude.
			F	19	37	21					
29	21 Nov.	I_d	e	20	09	16					Minute irregular waves on horizontal components only.
			F	20	09	45					
30	21 Nov.	I_d	i	21	51	12					Thickening of pen traces on horizontal components.
			F	21	51	15					
31	24 Nov.	I_d	i	18	45	47					Rapid pen strokes. Abrupt ending.
			F	18	45	58					
32	24 Nov.	I_d	e P	19	42	44					Strong thickening of pen trace. Preliminary tremors not perceptible on E-W component.
			L	19	42	47					
			F	19	42	53					
33	25 Nov.	III_d	i P	11	03	08					Δ=42.4 km.
			i L$_E$	11	03	12					Very rapid pen strokes superimposed on vibrations having a period of approximately 7^s.
			i L$_{NV}$	11	03	13					
			M$_E$	11	03	13	$<\frac{1}{2}$	75			
			M$_{NV}$	11	03	16	$<\frac{1}{2}$		88	28	
			C	11	03	26					
			F	11	05	32					
34	25 Nov.	I_d	i P	19	49	10					Thickening of pen trace.
			F	19	49	19					
35	11 Dec.	I_d	*O*	*23*	*26*	*29*					Δ=50 km.
			e P$_E$	23	26	37					
			i P$_N$	23	26	35					
			i P$_V$	23	26	34					
			i LM$_E$	23	26	42	$\frac{1}{2}$	16			
			i LM$_N$	23	26	40	$\frac{1}{2}$		19		
			F	23	27	32					
36	19 Dec.	I_v	*O*	*13*	*58*	*14*					Δ=216 km.
			i P$_N$	13	58	46					Not recorded on *V*. Gradual beginning on E-W.
			L$_E$	13	59	18					
			L$_N$	13	59	17					
			M$_E$	13	59	22	1.3	6			
			M$_N$	13	59	22	2		16		
			C	13	59	53					
			F	14	01	33					
	1920										
37	1 Jan.	I_v	e P$_E$	2	36	49					Not recorded on *V*.
			e P$_N$	2	36	36					
			L(?)	2	37	11					
			M$_E$	2	37	41	$2\frac{1}{2}$	3			
			M$_N$	2	37	21	$2\frac{1}{2}$		6		
			F	2	41	03					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1920			h m s	s	μ	μ	μ	
38	2 Jan.	$I_{(v)}$?	e P	13 19 53					No record on *V*. Inception of *L* doubtful.
			e $L(?)_N$	13 21 47					
			F	13 32 03					
39	3 Jan.	I_d	i P	22 12 53					Very rapid vibrations. Phases not discernible. Not recorded on *V*.
			M_E	22 12 59		4			
			M_N	22 12 58			5		
			F	22 13 01					
40	4 Jan.	III_r	e $P_N(?)$	4 29 08					No record on *V*. Instruments apparently out of adjustment. See discussion in text.
			M_{N1}	4 38 46			21		
			M_{N2}	4 40 56			22		
			M_E	4 40 55		48			
			F	4 57					
41	9 Jan.	II_d	i P	9 05 58.8					Δ = 16 km. Moderate local shock. Extremely rapid vibrations.
			i LM	5 06 00	.8	31	27		
			C	5 06 05					
			F	5 06 21					
42	11 Jan.	I_d	i P_V	13 01 27					Δ = 32 km.
			i LM	13 01 31		3	3		
			F	13 01 54					
43	14 Jan.	I_d	i	18 26 02					Strong thickening of pen trace on all components.
			F	18 26 05					
44	14 Jan.	I_d	i	19 54 54					Thickening of pen trace on all components.
			F	19 55 02					
45	20 Jan.	I_d	i	21 07 24					Strong thickening of pen trace on all components.
			F	21 07 36					
46	21 Jan.	I_d	i	21 26 54					Well developed maximum on N-S only.
			M_N	21 26 59			9		
			F	21 27 02					
47	23 Jan.	I_d	e P_N	1 10 46.2					Δ = 40 km. Not recorded on *V*.
			L_N	1 10 50.8					
			M_N	1 10 53.4	2		5		
			C	1 11 00					
			F	1 12 40					
48	24 Jan.	I_d	i	11 31 43					Thickening of pen trace on all components.
			F	11 31 49					
49	29 Jan.	I_d	i	23 53 54					Thickening of pen trace on all components.
			F	23 54 02					
50	30 Jan.	$I_{(r)}$?	e	18 51 06					Trace of a distant quake registered on E-W only.
			F	18 55 26					
51	31 Jan.	I_d	i	23 50 26					Thickening of pen trace.
			F	23 50 34					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1920			h m s	s	μ	μ	μ	
52	2 Feb.	III_u	e P	11 35 36					No record on *V*. Amplitudes small but much greater on E-W than on N-S. See discussion in text.
			e L	12 05 41					
			M	12 08 02	23				
			F	14 10					
53	4 Feb.	I_v	e P	12 42 12					Δ = 214 km. Not recorded on *V*.
			e L	12 42 42					
			M_N	12 42 46	2½		20		
			C	12 43 25					
			F	12 44 26					
54	5 Feb.	I_v	e P	9 09 59					No record on *V*. Inception of *L* doubtful.
			e L?	9 10 30					
			M_N	9 10 37	3		24		
			C	9 11 12					
			F	9 12 25					
55	10 Feb.	I_u	e	22 23 38					See Berkeley Station, No. 36.
			F	23 18					
56	11 Feb.	I_d	i	20 27 16					Thickening of pen trace on all components.
			F	20 27 22					
57	11 Feb.	II_d	i P	21 34 53					Δ = 22 km.
			i LM_N	21 34 55	<½		33		
			C	21 35 06					
			F	21 35 41					
58	12 Feb.	I_d	i	17 31 48					Thickening of pen trace on all components.
			F	17 31 59					
59	19 Feb.	I_d	i	0 28 08					Thickening of pen trace on all components.
			F	0 28 13					
60	15 Mar.	$I_{(r)}$?	e	12 42 03					Trace of a distant quake on horizontal components only.
			F	13 03					
61	20 Mar.	II_v	*O*	*17 48 43*					Δ = 330 km.
			e P	17 49 30					
			e S	17 50 07					
			e L	17 50 19					
			M_{N1}	17 51 02	3		65		
			M_E	17 51 22	4	78			
			M_{N2}	17 51 34	3		60		
			M_{N3}	17 52 12	7		60		
			C	17 55 54					
			F	18 00					
62	29 Mar.	II_r	*O*	*5 08 13*					Δ = 1480 km. Not recorded on *V* due to defective adjustment.
			e P	5 11 2[illegible]					
			e L	5 14 43					
			M_N	5 18 30	9		16		
			F	6 02					

DISCUSSION OF PARTICULAR SHOCKS

The Mexican Earthquake of January 4, 1920

On January 4, 1920, a destructive earthquake shock was reported from Mexico. Press reports located the area of maximum disturbance in the vicinity of Mt. Orizaba, about seventy miles west of Vera Cruz. The Berkeley and the Lick Observatory Station records of this shock present some interesting peculiarities.

At the Berkeley Station, the energy transmitted by the shock was not sufficient to register on the sheet written by the Omori tromometer, but the seismograms of the Wiechert vertical, and the N-S and E-W component Bosch-Omori instruments, when taken together, afford a fairly satisfactory record of the quake. At the time of the arrival of the P waves, persistent microseisms were being registered on the horizontal components. These, however, do not appear on the vertical, and here an excellent *emersio* of the P waves appears at $4^h\ 28^m\ 16^s$. It was several seconds later before motion which could be distinguished from the microseisms was recorded on the horizontal components. Except on the vertical component, the amplitudes of the P waves are exceedingly small as compared with those of the S and L phases.

On the E-W component there appears at $4^h\ 33^m\ 11^s$ a new phase marked by an increase in both period and amplitude. Comparison with the other components shows a similar change of character, though far less sharply marked, at approximately the same time. This constitutes the only appreciable change in the nature of the record before the arrival of the long waves. The change is therefore interpreted as the arrival of the second preliminary tremors.

The only clue as to the time of inception of the main phase is obtained from the N-S component. On it there is a suggestion of the arrival, at $4^h\ 36^m\ 02^s$, of waves of longer period, which, although complicated by the continuance of S waves for several minutes, soon increase rapidly in amplitude and become distinctly sinusoidal. The interpretation of this time as the beginning of the main phase is consistent with the preceding part of the record.

On the other two components S waves effectively mask the probable beginning of the main phase, and it is not until some two minutes later than the time given above for its inception, that characteristic L waves begin to dominate the records.

The maxima occur at approximately the same time on all components. The waves at the time of the maximum were of notably longer period on the N-S component than on V and E-W. The latter two had equal periods. The maximum displacement was twenty-five per cent greater on E-W than on N-S.

The Lick Station records were very unsatisfactory. Due presumably to defective adjustment, they were poorly written, and little of value could be learned from them.

Brazilian Earthquake of February 2, 1920

The disturbance set up by this destructive earthquake in the province of Minas Geraes, Brazil, affected the three sensitive instruments of the Berkeley Station for almost three hours. The seismograms appear typical of a teleseismic record, but certain puzzling inconsistencies developed when the measurements were made.

The arrival of the first preliminary tremors was best marked on the vertical component where an *emersio* sets in at $11^h\ 35^m\ 08^s$. About ten seconds later the first perceptible movement appears on the horizontal components. The P waves have a period of about four seconds and the amplitudes are very small. They continue for approximately two minutes on the vertical component, and less on E-W and N-S. Thereafter only a little irregular motion is observable until $11^h\ 45^m\ 53^s$, when there is a decided revival of movement on N-S. The new waves are of longer period than the preceding, but at first show superimposed vibrations similar in period and amplitude to the P waves. If this point has been correctly interpreted as the beginning of the S phase, it is peculiar that no corresponding change in character is observed until twenty-two seconds later on the E-W component and fifty-three seconds later on V. However these latter points are no less inconsistent with the other components, and are less sharply marked than the change on N-S which is taken as the arrival of S waves.

The main phase is interesting because of its long duration and also because of the strikingly smooth, regular, sinusoidal waves which characterize it throughout. There is a notable rhythmic succession of groups of waves of greater amplitude alternating with groups of less. Maxima on E-W and V occur close together. Periods and amplitudes are equal. Compared with the horizontal, the vertical amplitude is extraordinarily large. It is difficult to pick a definite maximum on N-S. The greatest displacement recorded on that component occurred some thirty-three minutes later than the maxima on V and E-W, and gave a calculated amplitude only one-ninth as great. The period at this time was notably less on all components than at the time of the preceding maximum.