UNIVERSITY OF CALIFORNIA PUBLICATIONS
BULLETIN OF THE
SEISMOGRAPHIC STATIONS
No. 1, pp. 1-10 January 2, 1912

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EQUIPMENT OF THE BERKELEY STATION

A Seismographic Station equipped with modern apparatus has recently been established at the University of California under the charge of the Department of Geology. It succeeds and takes the place of the seismographic station so long maintained at the Students' Observatory by the Astronomical Department of the University of California. The new station has been in effective operation since the 30th of October, 1910, though its projected equipment is not yet complete. It will be referred to briefly as the Berkeley Station to distinguish it from other stations in California. The following pages constitute the first report upon the establishment and wor kof the Berkeley station.

The seismographic instruments are set up in a basement room in the University Library. This is a new building of very solid. steel-frame construction. The instruments are seated upon piers of concrete which project up through openings cut in the floor and extend down to the firm rock which is found only a few inches below the floor level. The apparatus is wholly isolated from the structure. The bedrock here is an indurated sandstone of the Franciscan Series. Consequently the elastic waves of seismic disturbances reach the seismographs with very little local modification. In this respect the installation is considered to be exceptionally good.

The equipment of the station comprises the following instruments:

Two 100-kilogram Bosch-Omori Tromometers complete with dampers and registration apparatus, obtained from J. and A. Bosch in Strassburg. These horizontal pendulums are installed so that the plane of suspension of one is in the meridian, and that of the other at right angles to it. These therefore register the E-W and the N-S components of seismic motion respectively. Both have been adjusted so that they have periods of 15 seconds, magnification factors of 80 times, and damping factors of 8 to 1.

An 80-kilogram Wiechert Vertical Seismograph obtained from Spindler & Hoyer in Göttingen. This instrument required a long time for "settling" and during this period its adjustments were changed from time to time. During most of the time covered by the following report this seismograph has been adjusted to have a period of 6 seconds and a factor of damping of 8 to 1. Its magnification factor has been made approximately 80 times.

A horizontal-pendulum tromometer designed by Omori and constructed under his direction in Japan, intended particularly for the registration of nearby shocks. This instrument was transferred to this station from the Berkeley Astronomical Department of the University. When it was dismounted for the transfer, advantage was taken of the opportunity to give the instrument a thorough mechanical overhauling. In consequence of this and the pressure of other duties it has not yet been remounted.

In process of construction and nearing completion is an inverted-pendulum seismograph designed by Professor C. F. Marvin of Washington, D. C., for the registration of strong motion. This is being made by V. Arntzen in the workshop of the Department of Civil Engineering.

The time-marking magnetic devices of all the instruments

in active service are operated and controlled by a high-grade, break-circuit chronometer, no. 488, of the make of Wm. Bond & Sons of Boston, which for an instant every minute releases current from storage cells through the circuit which operates the magnets. The storage cells are installed so that one battery may be charged while the other is in use. By means of a telegraph sounder in circuit with the mean time clock at the Student's Observatory the chronometer is compared with the clock daily.

The time actually employed in the station is the Standard Mean Time of the 120th meridian, but in the systematic report upon recorded earthquakes all time determinations are reduced to Greenwich Mean Civil Time.

SPECIAL FEATURES

This seismographic station is situated within or on the eastern margin of the "circumpacific geosynclinal" which is recognized by de Montessus de Ballore as one of the two zones of predominant seismic activity in the world. This zone is a comparatively narrow belt extending along the western coasts of South and North America and on by way of the Aleutian Islands to the coasts of Japan and the Malaysian Islands. This follows approximately a great circle of the globe which, along the Californian coast, takes a north-northwest, south-southeast direction. It is to be expected, then, that a considerable majority of the earthquakes registered here, especially those from moderately great distance, will emanate from foci lying either to the north-northwest or to the south-southeast of this station. In a certain measure the shocks already registered confirm this opinion.

Professor C. G. Knott, in summarizing present views as to the character of the earth motion during various stages of a seismic disturbance, states that "longitudinal displacements predominate in the first preliminary phase and the third phase of the large waves, and the transverse displacements in the second phase and in earlier phases of the large waves." This generalization forecasts the detection of the following peculiarities in the seismograms of the majority of distant shocks registered here. The first preliminary tremors and the later part of the principal motion, consisting predominantly of longitudinal waves, should be better marked and of larger amplitude in the N-S component than in the E-W component unless local conditions interfere; also the second preliminary tremors and the earlier part of the chief phase should be better marked in the E-W component than in the N-S component.

In agreement with this prediction, the earlier part of the chief phase of most of the earthquakes of distant origin so far registered has been much better marked in the E-W component. For example, on the seismograms of the great shock originating in Russian Turkestan near midnight of January 3-4, 1911, the maximum amplitudes in the E-W and N-S components of the principal portion were 500μ and 70μ respectively. The short-arc path from this station to the origin has a direction about N 15° W. Nevertheless one or two earthquakes have been registered in which the N-S component showed the larger motion in the principal portion, indicating that such shocks emanated from origins outside this circumpacific zone, and at the same time demonstrating that the usual predominance of maxima in the E-W component is neither instrumental nor due to local conditions. The correspondence between theory and measurement in the other phases, the preliminary tremors and the later part of the chief phase, is less definite and satisfactory. For it is of course impossible to make all adjustments perfectly and it is unfortunately true that the writing point attached to the N-S pen causes more friction than that attached to the E-W pen. Though the difference is minute it is sufficient to make doubtful any conclusions in the case of small movements. It no doubt enters as a factor in the larger movements of the chief phase, but the differences here are too great for it to control. Though it has been in operation for only a brief time the registration here already apparently confirms the conclusions reached by Omori, Marvin and Knott regarding the character of the large waves.

Although the station is equipped with instruments of modern

type in delicate adjustment, already several small shocks have occurred in California which have not been registered by them. Indeed in one or two cases no shock has been registered here when distinctly registered by Wiechert instruments installed at Santa Clara College, situated some fifty miles to the south-southeast. And in some cases when recorded at both stations the motion has been unquestionably greater at one or the other. Likewise shocks have been registered at this station which are not reported by that at Santa Clara College. The obvious conclusion is that many of our local earthquakes are shallow and feeble so that their energy is dissipated in a relatively short distance. Though they are manifestations of growing strains and emanate from zones of danger they are not strong enough to affect even the better seismographs at a moderate distance from their foci. Consequently for the study of such local shocks more stations suitably distributed are needed.

CONSTANTS

Constants of the Station

Latitude and longitude of the center of the seismographic room:

$\phi = 37° 52' 15''.9$ N. Lat.

$\lambda = 122° 15' 36''.6$ 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 Tromometer N-S component	15s	80	8-1
Bosch-Omori Tromometer E-W component	15s	80	8-1
Wiechert Seismograph Vert. component	6s	80	8-1

Symbols and Notation

1. *Character of the Earthquake*—

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

   d (terrae motus domesticus) Local shock (origin nearby, perceptible at the station).

   v (terrae motus vicinus) Near shock (origin less than 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 (origin more than 5,000 kilometers).

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 Vert. component of A.

No.	Date	Charac.	Phase	Time			Period T	Amplitude		Remarks
								A_E	A_N	
	1910			h	m	s	s	μ	μ	
1	30 Oct.	I	e	8	08±		15-20			Barely discernible sine
			F		50±					waves
2	2 Nov.	I	e	13	59.6		8-10			Simple well-marked sine
			M_E	14	03.7			5		waves
			C		05.5					
			F		17.					
3	4 Nov.	I	e	6	04	42	8-10			L very doubtful
			L		09	25	8-10			Waves somewhat irregular
			M_N		11	53			10	
			M_E		11	32		20		
			M_E		12	30		25		
			F		40.7					
4	5 Nov.	I v	e P	17	20	29				Relatively simple feeble
			S		20	59				waves
			i L		21	25	2±			Recorded also by the vertical
			M_N		21	28			5	seismograph
			M_E		22	05		7		
			F		24.7					
5	6 Nov.	III r	i P	20	34	32	2-4			Waves of chief phase show
			i S		37	22	4-6			simple superposed motions
			L		39	18	8-12			
			M_E		39	59		280		
			M_N		40	06			140	
			C		48.5					
			F	22	50±					
6	8 Nov.	I d	P	18	36	32	1-2			Not reported felt here
			M_E		36	35		3		
			M_N		36	46			3	
			F		39.7					
7	9 Nov.	III u	e P	6	14	43				N-S record defective
			i S		25	53				Three well-marked groups of
			i L		40	45	25-30			large waves in chief phase
			M_E		43	24	20-25	100		from
			"		59	38	15-18	110		h m h m
			"	7	03	45	15-20	90		(*a*) 6 42.7 to 6 47.7
			C		06.7					(*b*) 6 55.7 " 7 01
			M_E	8	29	44	15-20	15		(*c*) 7 02 " 7 07
			"		40	11	15-20	25		and two groups in the tail
			F	9	20±					phase
										(*d*) 8 28.7 to 8 31
										(*e*) 8 39 " 8 43
8	10 Nov.	II u	P	?	?					Registered also by vertical
			e S	12	42.7					seismograph
			e L		57.7		30			Chief phase a simple sine
			M_E	13	01.7		20-25	330	3	curve for many minutes
			F		44					dying away gradually

No.	Date	Charac.	Phase	Time h	m	s	Period T	Amplitude A_E	A_N	Remarks
	1910			h	m	s	s	μ	μ	
9	26 Nov.	III u	e P	4	53	46				Registered by vertical seis-
			i S	5	05	24	10-15			mograph
			L		19	42	30			Chief phase a simple sine
			M_E		24	24	20-25	250	10	curve
			C		32.5					
			F	7	35±					
10	3 Dec.	I	e	8	43.7					Motion barely perceptible
			F	9	08.7					Long flat waves in N-S
										component only
										Dying motion of chief phase
11	3 Dec.	I	e	14	06±		1-2			Barely discernible short
			F		07.7					waves
12	4 Dec.	I	e	11	54±		10-20		5	Dying chief phase of feeble
			F	12	26±					distant shock
13	5 Dec.	I d	e	20	24	50				Motion barely discernible in
			F		25	50				E-W component only
14	10 Dec.	II u	i P	9	39	21	2-3			Waves of chief phase are
			i S		50	01	5-10			irregular showing com-
			L	10	05	15	20-25			pounded motion, with re-
			M_E		06	49		40	3	curring maxima
			"		08	44		40		Registered by vertical seis-
			C		30±		12-15			mograph also
			F	12	27					
15	12 Dec.	I	e	0	02					Dying waves of chief phase
			L		15		8-10			scarcely discernible
			F		30±					
16	12 Dec.	I d	e	17	28	46	short			Barely perceptible short
			F		30	10				waves
17	13 Dec.	III u	e P	11	57	12	3-5			Chief phase a sine curve
			S	indefinite						
			L	12	51	17	20			
			M_E	13	00	06	to	780		
			M_N		01	32	30		10	
			C		15					
			F	14	30±					
18	14 Dec.	I	i P	20	57	17	2-4			
			S (?)	21	01	18				
			L		06	20	5-8	15		
			M_E		06	47				
			F	22	00					
19	16 Dec.	III u	e P	15	03	52	4-6			Waves of 1st and 2nd Phases
			L		46	34	20-15			very irregular, of chief
			M_E		48	28	18	60		phase a simple sine curve
			M_N		52.7				2	

No.	Date	Charac.	Phase	Time h	m	s	Period T	Amplitude A_E	A_N	Remarks
	1910			h	m	s	s	μ	μ	
19	16 Dec.	III u	M_E		53	27		63		*Registration apparatus
			M		58	55		75	2	stopped at this time
			M_N	16	02.7				2	
			M_E		05	52	15	100		
			*F		43					
20	19 Dec.	I d	i	13	01	05				Clock correction uncertain
			M		01	13	1-2	3		Barely discernible
			F		03					
21	28 Dec.	I	i	17	33.7		1-3			Motion scarcely perceptible
			F		37					
22	28 Dec.	I	i	18	08.5					Scarcely perceptible short
			F		11					waves
23	31 Dec.	III d	i P	12	11	19	1-2			Felt, II-III R.-F. scale
			L		11	37	3-5			Short tangled waves
			M_E		11	38		130	60	Vertical component regis-
			C		11	48				tered
			F		20.5					
	1911									
24	2 Jan.	I u	e	11	14±					Movement in N-S component
			M_E		45±		15	5		very slight
			F	12	30±					
25	3 Jan.	III u	i P	23	39	22	3-5			Origin near Issykul in Rus-
			i S		52	13	5-8			sian Turkestan
			L	indefinite			25			Waves of 1st and 2nd phases
	(4 Jan.)		M_N	0	21	47	25		70	show superposed motions
			M_N		24	47	20		55	Large waves more regular
			M_E		25	28	20	300		Maxima recur in chief phase
			M		27	55	15	500	60	and in tail phase
			M_E		30	03	15	300		
			M_E		33	54	20	290		
			F	2	20±					
26	7 Jan.	I	e	3	52±		10-15	3		Dying waves of chief phase
			F	4	40±					of a distant shock
27	9 Jan.	I	e P	21	25	44	½-1			
			L		25	53		3	2	
			F		26±					
28	10 Jan.	I d	i P	23	17	32	¼-1			Clock correction uncertain
			i L		17	51	2-3			
			M_E		17	53		10		
			M_N		17	57			6	
			C		18	02				
			F		20					
29	12 Jan.	I d	e P	5	34	08	½-1			Tangled waves
			i L		34	23				

No.	Date		Charac.	Phase	Time			Period T	Amplitude		Remarks
									A_E	A_N	
	1911				h	m	s	s	μ	μ	
	12	Jan.	I d	M_N		34	28		7	5	
				C		34	40				
				F		36					
30	30	Jan.	I d	e	23	43	10				Record barely discernible
				F		43	25				
31	7	Feb.	I d	i P	13	19	10	$\frac{3}{4}$-$1\frac{1}{2}$			
				i L		19	26				
				M_N		19	27			8	
				M_E		19	38		10		
				F		21±					
32	18	Feb.	I u	e	1	58					Dying chief phase of distant shock—waves irregular sine curve
				M	2	08		10-15	12	4	
				F		40					
38	18	Feb.	II u	e	19	23		15-20			Motion N-S component, barely perceptible
				L		40.7		25			
				M_E		45.5		20	110	5	
				F	20	30					
34	11	Mar.	I u	e	3	58±					Long flat waves, barely perceptible
				F	4	50±					
35	11	Mar.	II d	i P	21	29	45	$\frac{1}{2}$-1			
				L		30	13	1-3			
				M_E		30	36		45		
				M_N		30	40			20	
				F		35+					
36	13	Mar.	I u	e	11	27.7		15-18	5		E-W component only
				F		45					Barely perceptible long flat waves
				e	4	14+		1-3			Phases indistinguishable
37	29	Mar.	I	F		19					Scarcely perceptible