SEISMOLOGICAL OBSERVATORY BULLETIN

UNIVERSITY OF PITTSBURGH

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SEISMOLOGICAL OBSERVATORY BULLETIN

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Paper by

MR. FRED KELLER

on

"An Electronic Seismograph Recorder"

PITTSBURGH, PENNSYLVANIA

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(This Bulletin is issued yearly)

STATION CONSTANTS AND INSTRUMENTS

Latitude—40° 26.7′ North

Longitude—79° 57.2′ West

Lithological foundation—Birmingham Shale—Pennsylvania age.

Elevation—273 meters above sea level.

Instruments

Two Wenner horizontal seismographs (Orientation N30°W and N60°E)

One Benioff vertical seismograph (long period recording only)
(The above instruments operate with photographic recording)

Two Pittsburgh Type mechanically recording seismographs
(Orientation N-S and E-W)

Time Service and Control

Time marks are given by two Observatory master clocks; one is a special astronomical type (used as stand-by), while the other is a Frodsham astronomical clock, (used for routine work).

Time signals are recorded automatically (or manually, depending on the weather conditions) several times daily. These signals are transmitted from Washington, D. C. via stations NSS and WWV, and from Ottawa via station CHU.

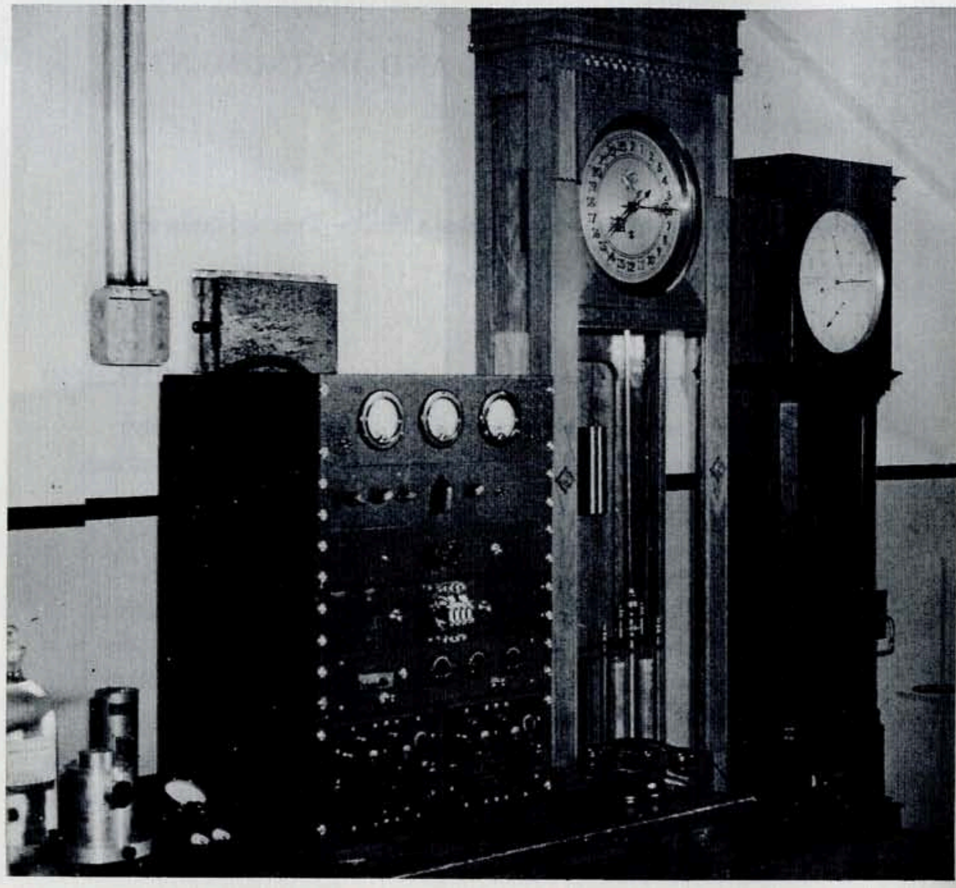
The average clock drift is one-half second per day.

Instrumental Constants

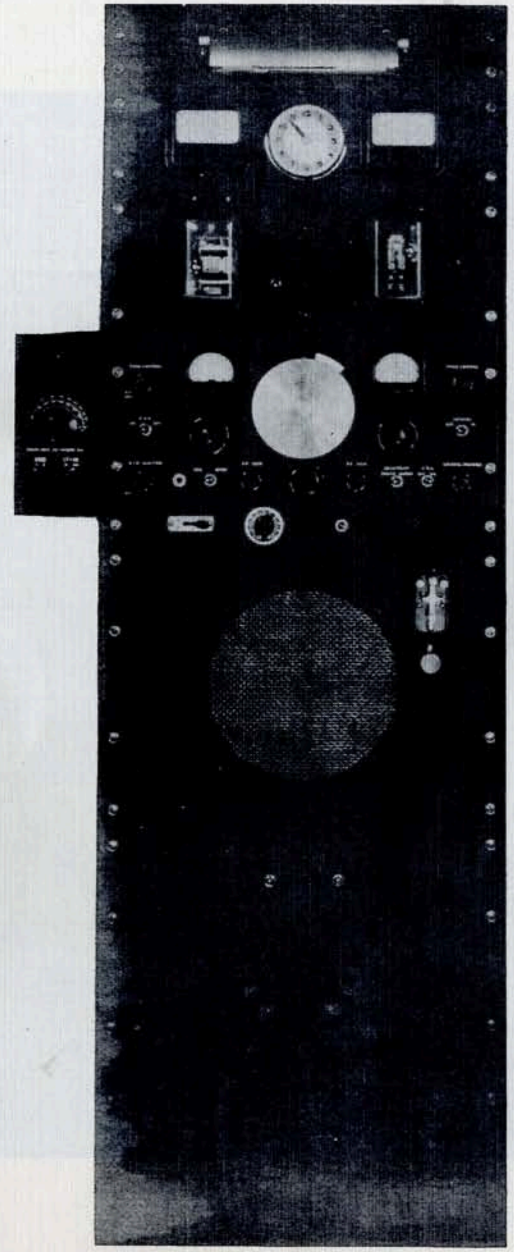
Magnification curves for the Wenner seismographs were given in No. 1 of this Bulletin. The magnification curve for the Benioff is not yet completed. The "nominal" magnification for this instrument is approximately 24,000.

The New Instrument Vault

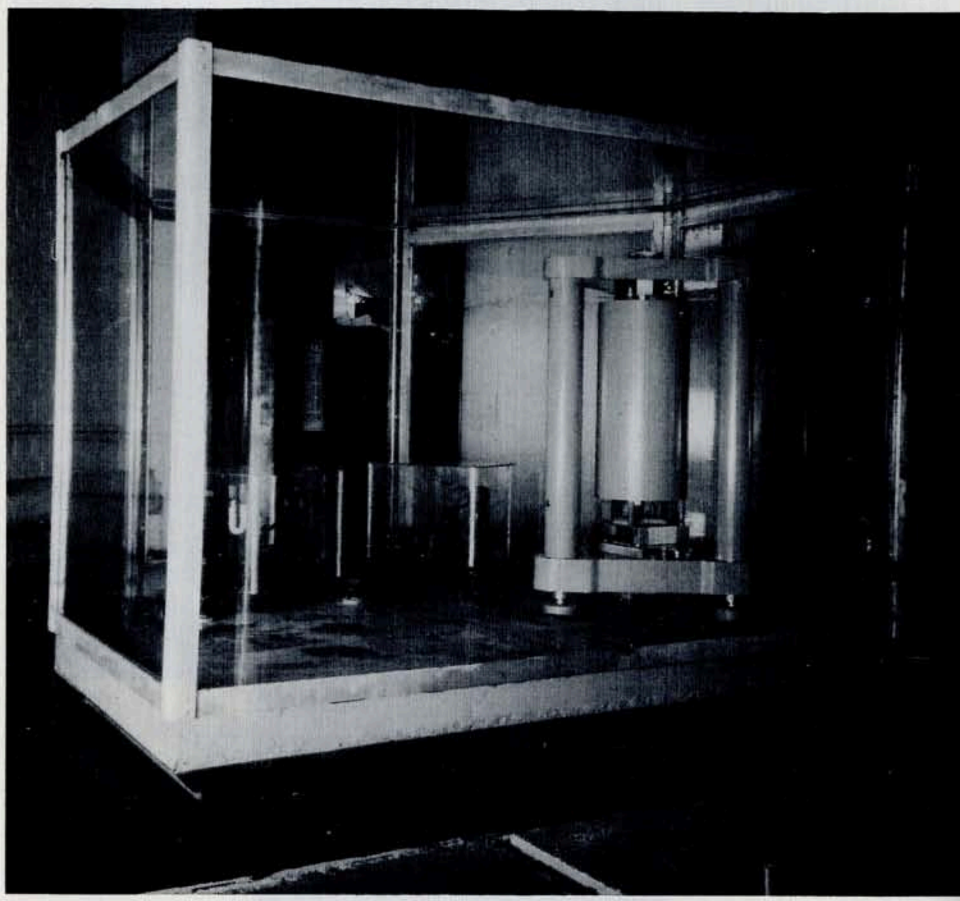
A new instrument vault is being built in the Cathedral of Learning to house the mechanically recording pendula. Included in this vault will be an interferometer type tiltmeter and a well gage recorder. Construction has been halted for the duration of the war.



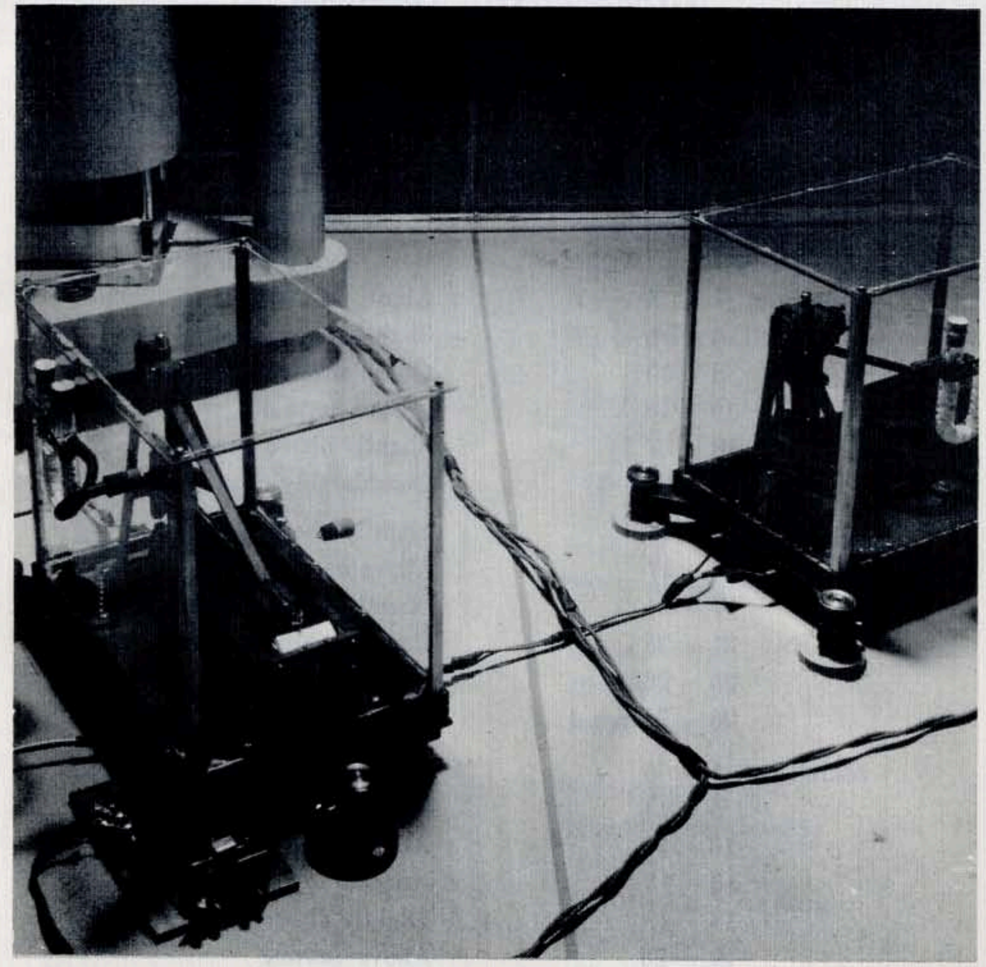
OBSERVATORY CLOCKS AND CONTROL PANEL IN SEISMIC VAULT



PICTURE OF ELECTRICAL PANEL FOR LONG AND SHORT WAVE RECEPTION OF TIME SIGNALS.



VIEW OF MAIN INSTRUMENT PIER.



INDIVIDUAL GLASS CASES WENNER SEISMOMETERS

MICROSEISMIC ACTIVITY

These data have been evaluated according to the following scale

HORIZONTAL AMPLITUDE	DESIGNATION
Less than 2 microns	below normal
Between 2 and 3 microns	normal
More than 3 microns	above normal

DATE		EVALUATION
January	1 – 4	Above normal
	4 – 8	Slightly above normal
	8 - 10	Considerably above normal
	10 – 18	Above normal
	18 – 27	Slightly above normal
	27 – Feb. 1	Considerably above normal
February	2 – 14	Slightly above normal
	14 – 17	Above normal
	17 – 24	Slightly above normal
	24 – 25	Considerably above normal
	25 – 26	Above normal
	26 – March 1	Considerably above normal
March	1 – 5	Above normal
	5 – 13	Slightly above normal
	13 – 16	Above normal
	16 – 18	Normal
	18 – 19	Slightly above normal
	19 – 23	Above normal
	23 – 26	Normal
	26 – 31	Slightly above normal
April	1 – 3	Normal
	3 – 5	Slightly above normal
	5 – 9	Normal
	9 – 11	Above normal
	11 – 14	Slightly above normal
	14 – 26	Normal
	26 - 30	Slightly below normal

MICROSEISMIC ACTIVITY (Cont'd)

DATE		EVALUATION
May	1 - 10	Slightly below normal
	10 - 14	Below normal
	14 - 17	Normal
	17 - 18	Slightly below normal
	18 - 23	Below normal
	23 - 24	Normal
	24 - 31	Slightly above normal
June	1 - 5	Below normal
	5 - 8	Normal
	8 - 10	Slightly above normal
	10 - 16	Below normal
	16 - 18	Normal
	18 - 30	Below normal
July	1 - 16	Below normal
	16 - 17	Normal
	17 - 31	Below normal
August	1 - 19	Below normal
	19 - 24	Slightly below normal
	24 - 31	Normal
September	1 – 4	Slightly less than normal
	4 – 7	Normal
	7 – 8	Above normal
	8 – 20	Below normal
	20 – 23	Normal
	23 – 24	Above normal
	24 – 27	Below normal
	27 – 28	Normal
	28 – 29	Above normal
	29 – 30	Above normal

October	1 – 3	Normal
	3 – 6	Considerably above normal
	6 – 7	Above normal
	7 – 10	Normal
	10 – 15	Above normal
	15 – 19	Normal
	19 – 21	Considerably above normal
	21 – 22	Normal
	22 – 26	Slightly below normal
	26 – 27	Normal
	27 – 28	Considerably above normal
	28 – 29	Above normal
	29 – 31	Slightly below normal
November	1 – 2	Normal
	2 – 4	Above normal
	4 – 8	Normal
	8 – 9	Slightly below normal
	9 – 13	Normal
	13 – 18	Above normal
	18 – 19	Slightly above normal
	19 – 20	Normal
	20 – 21	Considerably above normal
	21 - 22	Above normal
	22 - 25	Slightly above normal
	25 - 29	Above normal
	29 - 30	Considerably above normal
December	1 – 4	Above normal
	4 – 5	Considerably above normal
	5 – 7	Slightly above normal
	7 – 12	Normal
	12 – 15	Above normal
	15 – 31	Considerably above normal

SECTION ON SEISMIC DATA

(Earthquakes for which preliminary phases have been identified, or for which preliminary epicenters have been worked out, are numbered in the left hand column as of No. 1, September 8, 1939.) It was on this date that our new station was placed in operation.

	GNWCH. DATE	COMPNT.	PHASE	GMT	
68	Jan. 20	Z	iP	06-32-05	Δ(S-P) = 34.1° = 3,790 kms.
		Z	i	06-32-06	H = 06h-25m 17s (G.M.T.)
		H	e	06-37-22	U.S.C. and G.S. gives
		H	e	06-37-30	Δ = 5,000 kms.
		H	iS	06-37-39	H = 06h 25.6m U.T.
					Lat. 17.5° North
					Long. 106° West
	Jan. 27	Seismic activity centering about 14h 36m (G.M.T.)			
	Jan. 31	Seismic activity centering about 07h 08m (G.M.T.) Indications are that the epicenter is within 1000 mi.—no data available.			
	Feb. 11	Seismic activity centering about 11h 39m (G.M.T.)			
	Feb. 13	Seismic activity centering about 07h 24m (G.M.T.)			
	Feb. 16	Seismic activity centering about 19h 12m (G.M.T.)			
69	Feb. 21	Z	iP	07-20-56	Δ(S-P) = 91.8° = 10,200 kms.
		Z	i	07-21-07	H = 07-07-49 (G.M.T.)
		H	eScPcS	07-31-22	
		H	iS	07-31-59	
		H	i	07-32-30	
	Feb. 23	Seismic activity centering about 04h 05m (G.M.T.)			
	Feb. 23	Seismic activity centering about 07h 46m (G.M.T.)			
70	Mar. 5	Z	iP	20-00-37	Δ(S-P) = 81.2° = 9,020 kms.
		Z	ipP	20-01-37	H = 19h 48m 53s
		H	iS	20-10-38	depth = 270 kms.
		H	i	20-11-55	U.S.C. and G.S. gives
					Δ = 9,900 kms.
					H = 19h-48.2m
					depth = 250-300 kms.
	Mar. 6	Seismic activity centering about 21h 18m (G.M.T.)			

	GNWCH. DATE	COMPNT.	PHASE	GMT	
	Mar. 19	Seismic activity centering about 10h 27m (G.M.T.) Preliminary phases absent but long waves are of great amplitude.			
	Mar. 19	Seismic activity centering about 22h 10m (G.M.T.) Long waves distinct but no preliminary phases			
	Mar. 22	Seismic activity centering about 00h 20m (G.M.T.)			
	Mar. 30	Seismic activity centering about 09h 35m (G.M.T.)			
	Apr. 8	Seismic activity centering about 06h 10m (G.M.T.)			
71	Apr. 8	Z	eP	15-59-18	Δ(S-P) = 100.2° = 11,135 kms
		H	i	16-01-00	H = 15h 43m 31s
		H	iS	16-10-57	
72	Apr. 11	Z	eP	01-30-50	Δ(S-P) = 27.8° = 3,090 kms.
		Z	iP	01-30-48	H = 01h 24m 57s
		H	iS	01-35-40	U.S.C. and G.S. gives
					H = 01h 25.1m U.T.
					Lat. 15.0° North
					Long. 91.5° West
					distance = 3,025 kms.
					depth = 100 kms.
73	Apr. 13	Z	i	08-57-51	U.S.C. and G.S. gives
		H	iS	09-07-15	H = 07h 46.1m U.T.
					Lat. 3.0° South
					Long. 13.0° West
					distance = 8,260 kms.
	Apr. 22	Seismic activity centering about 23h 45m (G.M.T.)			
	May 6	Seismic activity centering about 06h-08m (G.M.T.)			
74	May 14	Z	iP	02-21-00	Δ(S-P) = 37.2° = 4,135 kms.
		Z	i	02-21-04	H = 02-13-47
		H	i	02-21-10	U.S.C. and G.S. gives
		Z	i	02-21-12	H = 02h 13.3m U.T.
		H	i	02-21-13	Δ = 4,640 kms.
		Z	i	02-21-29	Lat. 1° North

	GNWCH. DATE	COMPNT.	PHASE	GMT	
	May 14	H	i	02-21-32	Long. 79° West
	(cont'd)	Z	i	02-21-39	
		Z	i	02-22-02	
		H	i	02-22-07	
		Z	i	02-22-50	
		H	i	02-24-01	
		H	iS	02-26-56	
		H	Finis at 06H 10m		
		H	eS	08-52-36	aftershock?
					U.S.C. and G.S. gives
					Δ = 4,320 kms.
					H = 08h 39.0m U.T.
					Lat. 1°5 North
					Long. 81°5 West
	May 15	H	e	11-04-15	
		H	i	12-04-59	
	May 17	Seismic activity centering about 15h 32m (G.M.T.)			
	May 24-June 5	Station closed for annual repair and adjustment.			
	June 7	Seismic activity centering about 11h 10m (G.M.T.)			
	June 9	Z	i	09-41-34	
	June 9	Seismic activity centering about 11h 32m (G.M.T.)			
	June 10	Seismic activity centering about 11h 30m (G.M.T.)			
	June 12	Seismic activity centering about 02h 55m (G.M.T.)			
75	June 12	Z	iP	10-29-35	Δ(S-P) = 42.5° = 4,720 kms.
		H	iS	10-36-04	H = 10-21-40 (G.M.T.)
					U.S.C. and G.S. gives
					H = 10h 21.5m U.T.
					Δ = 4,925 kms.
					Lat. 2°5 South
					Long. 77°0 West

	GNWCH. DATE	COMPNT.	PHASE	GMT	
76	June 16	Z	iP	21-12-49	Δ(S-P)=40°0=4,445kms
		H	i	21-14-28	H=21hv-05m-14s (G.M.T.)
		H	iS	21-19-03	U.S.C. & G.S. gives
					H = 21h-05.2m U.T.
					Δ = 4,450 kms.
					Lat. 0° North
					Long. 81° West
	June 18	Seismic activity centering about 11h-10m., (G.M.T.)			
77	June 20	Z	iP	10-07-44	Δ=32.9°=3655 kms.
		Z	ipP	10-08-15	H=10-01-05 (G.M.T.)
		H	iS	10-13-00	depth=200 kms. approx.
		H	isS	10-13-37	
	June 21	Z	i	04-50-36	
		H	i	05-00-25	Little or no long waves indicating depth
	June 22	Seismic activity centering about 20h-12m., (G.M.T.)			
	June 23	Seismic activity centering about 09h-09m., (G.M.T.)			
	June 24	Z	i	11-35-25	
		H	i	11-37-13	
		H	e	11-42-26	
78	June 29	Z	eP	06-38-03	Δ(S-P) = 72.7° = 8,080 kms.
		Z	iP	06-38-05	H = 06-26-52
		Z	i	06-38-27	depth = 110 kms.
		Z	i	06-38-37	U.S.C. and G.S. gives
		H	i	06-40-54	Δ = 8,350 kms.
		H	iS	06-47-26	H = 06h 26.1m U.T.
		H	i	06-47-57	
		H	isS	06-48-06	Lat. 34°5 South
					Long. 70°5 West
	July 3	Seismic activity centering about 03h 50m (G.M.T.)			

	GNWCH. DATE	COMPNT.	PHASE	GMT	
79	July 4	H	eP ?	02-00-21	Δ(S-P) = 38.2° = 4,245 kms.
		H	eS ?	02-06-24	H = 01h 53m 00s (G.M.T.)
					U.S.C. and G.S. gives
					H = 01h 53.1m G.C.T.
					Lat. 0.6° North
					Long. 80.9° West
					Δ = 4,400 kms.
80	July 4	H	eP	06-16-08	Δ(S-P) = 39.7° = 4,410 kms.
		H	i	06-16-53	H = 06h 08m 35s (G.M.T.)
		H	es	06-22-21	U.S.C. and G.S. gives
		H	i	06-23-43	H = 06 ho.8.6m (G.C.T.)
					Lat. 0.7° North
					Long. 80.9° West
81	July 5	H	e	10-36-56	U.S.C. and G.S. gives
		H	e	10-44-30	H = 10h 29.9m G.C.T.
					Lat. 1.4° North
					Long. 80.5° South
	July 7	Seismic activity centering about 03h 33m (G.M.T.)			
					U.S.C. and G.S. gives
					H = 02h 32.7m (G.C.T.)
					Lat. 0.9° North
					Long. 80.4° West
	July 7	H	e	12-45-20	
		H	i	12-46-55	
82	July 8	Z	iP	07-06-21	Δ(S-P)=67.1°(calc.)=7455 kms.
		Z	ipP	07-06-57	H = 06h 55m 50s (G.M.T.)
		H	iS	07-15-05	depth = 300 kms.
		H	isS	07-16-14	U.S.C. and G.S. gives
					H = 06h 55.5m (G.C.T.)
					Lat. 25°.5 South
					Long. 79°.5 West
					Δ = 7,400 ± kms.
	July 8	H	i	22-08-31	
		H	i	22-10-16	

	GNWCH. DATE	COMPNT.	PHASE	GMT	
83	July 12	Z	iP	05-12-58	Δ(S-P) = 35.1° = 3,900 kms.
		Z	i	05-13-09	H = 05-06-02 (G.M.T.)
		H	i	05-14-37	
		H	iS	05-18-37	
		H	i	05-19-01	
		H	i	05-19-17	
	July 21	Z	i	07-58-13	
		H	e	08-05-50	
	July 22	Seismic activity centering about 03h 40m (G.M.T.)			
	July 25	Z	iP	06-41-27	
		Z	i	06-41-48	
		H	i	06-43-24	
		H	i	06-48-22	
		H	i	06-49-52	
		H	i	15-34-50	
		H	i	15-37-41	
	July 29	Preliminary phases on vertical seismogram indiscernible			
		H	i	23-08-39	
		H	i	23-41-09	
		H	i	23-42-06	
	Aug. 1	Z	iP	12-53-02	
		Secondary phases on horizontal seismograms indiscernible			
84	Aug. 6	Z	iP	23-42-49	U.S.C. and G.S. gives
					Δ = 3,080 kms.
					H = 23h 37.0m U.T.
					Lat. 14.4° North
					Long. 90.9° West
	Aug. 6	Seismic activity centering about 06h 20m (G.M.T.)			
85	Aug. 8	Z	iP	07-25-20	Δ(S-P) = 34.1° = 3,790 kms.
		H	e	07-30-53	H = 07-18-12 (G.M.T.)
		H	iS	07-30-57	

No.	GNWCH. DATE	COMPNT.	PHASE	GMT	
86	Aug. 8	Z	iP	22-42-33	Δ(S-P) = 27.0° = 3,000 kms.
		H	eS	22-47-16	H = 22-36-48 (G.M.T.)
		H	i	22-47-45	U.S.C. and G.S. gives
					Δ = 3,080 kms.
					H = 22h 36.6m U.T.
					Lat. 14.4° North
					Long. 90.9° West
87	Aug. 11	H	eP	04-54-20(?)	Δ(S-P) = 31.9° = 3,545 kms.
		H	eS	05-00-13	H = 04-47-50 (G.M.T.)
	Aug. 11	Seismic activity centering about 07h 32m (G.M.T.)			
	Aug. 13	H	i	16-12-03	
		H	i	16-12-16	
	Aug. 14	Seismic activity centering about 21h 20m (G.M.T.) (no preliminary phases discernible)			
	Aug. 15	Seismic activity centering about 06h 50m (G.M.T.)			
88	Aug. 16	Z	iP	21-13-43	Δ(S-P) = 31.2° = 3,465 kms.
		H	eS	21-18-57	H = 21-07-20 (G.M.T.)
		H	iS	21-18-59	
89	Aug. 20	H	e(P)	22-43-29	Δ(S-P) = 29.9° = 3,320 kms.
		H	e(S)	22-48-34	H = 22-37-17 (G.M.T.)
		H	i	22-50-09	
		H	i	22-51-52	
		H	i	22-52-57	
	Aug. 22	H	i	02-25-18	
		H	i	02-25-26	
90	Aug. 23	Z	iP	06-46-41	Δ(S-P) = 70.9° = 7,880 kms.
		Z	i	06-46-46	H = 06-35-27 (G.M.T.)
		H	iS	06-56-02	U.S.C. and G.S. gives
					H = 06h 35.4m U.T.
					Δ = 8,180 kms.
					Lat. 51.5° North
					Long. 163° East

No.	GNWCH. DATE	COMPNT.	PHASE	GMT	
91	Aug. 24	Z	iP	23-00-04	Δ(S-P) = 52.4° = 5,820 kms.
		H	iS	23-07-35	H = 22-50-54 (G.M.T.)
					Other phases indiscernible due to overlapping of trace.
					U.S.C. and G.S. gives
					H = 22h 50.7 U.T.
					Δ = 6,100 kms.
					depth = 50-100 kms.
					Lat. 14.5° South
					Long. 75.5° West
92	Aug. 25	H	i(P)	20-27-27	Δ(S-P) = 36.8°=4090 kms.
		H	i	20-27-35	H = 20-20-17(G.M.T.)
		H	i(S)	20-33-20	
	Aug. 26	Z	iP	12-19-08	
		Z	i	12-19-20	
		H	e	12-25-48	
		H	e	12-26-14	
		H	e	12-26-32	
	Aug. 27	Z	iP	06-25-34	
		H	e	06-34-55	
	Aug. 29	Z	iP	01-19-01	
		Z	i	01-09:02	
93	Aug. 29	Z	iP	12-29-47	Δ(S-P) = 30.9° = 3,435 kms.
		Z	ipP	12-30-25	H = 12-23-26 (G.M.T.)
		H	e	12-34-05	
		H	e	12-34-45	
		H	e	12-35-18	
		H	i(S)	12-34-59	
		H	i	21-51-25	
94	Sept. 1	Z	iP	09-54-19	Δ(S-P) = 77.0° = 8,555 kms.
		H	iS	10-04-11	H = 09-42-49 (G.M.T.)
		H	i	10-04-23	

	GNWCH. DATE	COMPNT.	PHASE	GMT	
	Sept. 2	H	e	03-37-01	Preliminary phases indiscernible
					U.S.C. and G.S. gives
					H = 03h 17.1m U.T.
					Δ = 6,600 kms.
					Lat. 52.5° North
					Long. 170° West
	Sept. 4	Seismic activity centering about 03h 25m (G.M.T.)			
					U.S.C. and G.S. gives
					H = 02h 53.7m U.T.
					Δ = 3,300 kms.
					Lat. 12.5° North
					Long. 91.0° West
	Sept. 4	Seismic activity centering about 18h 28m (G.M.T.)			
					U.S.C. and G.S. gives
					H = 17h 46.2m U.T.
					Δ = 6,520 kms.
					Lat. 52.8° North
					Long. 169.2° West
	Sept. 6	Z	iP	16-04-43	
		Z	iP	16-03-49	
		H	e	16-13-42	
95	Sept. 9	Z	ipP	01-34-59	Δ(S-P) = 55.2° = 6,135 kms.
		H	i	01-37-09	H = 01-25-29 (G.M.T.)
		H	iS	01-42-47	U.S.C. and G.S. gives
		H	i	01-44-50	H = 01h 25.3m U.T.
					Δ = 6,270 kms.
					Lat. 53.1° North
					Long. 165.0° West
	Sept. 12	H	i	06-58-02	
	Sept. 24	Seismic activity centering about 04h 50m (G.M.T.)			
	Sept. 25	Seismic activity centering about 09h 10m (G.M.T.)			

	GNWCH. DATE	COMPNT.	PHASE	GMT	
96	Sept. 26	Z	iP	04-06-14	Δ(S-P) = 28.5° = 3,165 kms.
		Z	i	04-06-30	H = 04h 00m 15s (G.M.T.)
		H	i	04-06-56	U.S.C. and G.S. gives
		Z	i	04-07-05	H = 04h 00m 03s U.T.
		H	e	04-10-18	Δ = 3,160 kms.
		H	i	04-10-31	Lat. 12.8° North
		H	i	04-10-58	Long. 87.5° West
		H	eS	04-11-09	
		H	L	04-13-45	
		H	M	04-14-54	
	Sept. 27	Seismic activity centering about 17h 15m (G.M.T.)			
	Oct. 3	Seismic activity centering about 10h 36m (G.M.T.)			
	Oct. 8	Seismic activity centering about 03h 25m (G.M.T.)			
	Oct. 14	Seismic activity centering about 00h 40m (G.M.T.)			
	Oct. 20	Z	iP	23-40-53	
		Z	i	23-41-01	
		Other phases indiscernible due to overlapping trace and strong microseisms.			
97	Oct. 21	Z	iP	17-07-57	U.S.C. and G.S. gives
		Z	i	17-08-15	H = 16h 22m 15s U.T.
		Z	i	17-08-44	Δ = 3,300 kms.
					Lat. 33.1° North
					Long. 116.0° West
		Other phases indiscernible due to overlapping trace and strong microseisms.			
	Oct. 22	H	e	01-56-52	
		H	e	01-58-55	
		H	e	02-01-35	
		H	i	02-05-47	
98	Oct. 26	Z	iP	22-21-34	Δ(S-P) = 83.2° = 9,245 kms.
		Z	i	22-21-51	H = 22-09-10 (G.M.T.)

GNWCH. DATE		COMPNT.	PHASE	GMT	
	Oct. 26	H	i	22-31-44	U.S.C. and G.S. gives
		H	iS	22-31-56	H = 22h 09.0m U.T.
					Δ = 9,250 kms.
					Lat. 45° North
					Long. 150° East
	Nov. 6	Z	iP	13-39-30	
		H	e	13-47-00	
		H	i	13-47-12	
	Nov. 7	Z	i	07-55-06	
99	Nov. 10	Z	eP	12-00-39	U.S.C. and G.S. gives
		Z	e	12-00-41	Δ = 14,900 kms.
		Z	i	12-00-38	H = 11h 41.3m U.T.
					Lat. 35.0° East
					Long. 46.5° South
		Other phases indiscernible due to overlapping of trace.			
100	Nov. 12	Z	iP	05-01-24	Δ(S-P) = 26.6° = 2,955 kms.
		H	e	05-05-44	H = 04h 55m 43s (G.M.T.)
		H	iS	05-06-04	U.S.C. and G.S. gives
		H	i	05-06-14	Δ = 2,960 kms.
		H	i	05-06-25	H = 04h 55.4m U.T.
					Lat. 16.8° North
					Long. 94.2° West
	Nov. 19	Z	eP	08-59-33	
		Z	iP	08-59-35	
		Z	i	08-59-44	
		H	e	09-04-58	
		H	i	09-05-43	
101	Nov. 25	Z	iP	01-23-56	Δ(S-P) = 29.8° = 3,310 kms.
		H	eS	01-28-52	H = 01h 17m 45s (G.M.T.)
		H	iS	01-29-00	

GNWCH. DATE		COMPNT.	PHASE	GMT	
102	Nov. 26	Z	iP	14-39-49	Δ(S-P) = 81.4° = 9,045 kms.
		Z	i	14-40-21	H = 14h 27m 34s (G.M.T.)
		H	iS	14-50-02	
103	Nov. 28	Z	iP	10-47-53	Other phases indiscernible
		Z	i	10-48-16	Δ(eS-P) = 50.0° = 5,555 kms.
		H	eS	10-55-09	H = 10h 39m 00s (G.M.T.)
		H	iS	10-55-13	
104	Dec. 5	Z	iP	14-37-06	Δ(eS-P) = 88.4° = 9,820 kms.
		H	eS	14-47-53	H = 14h 24m 16s
		H	iS	14-48-01	
105	Dec. 9	Z	iP	22-28-52	Δ(S-P) = 52.1° = 5,790 kms.
		H	iS	22-36-21	H = 22h 19m 44s
106	Dec. 31	Z	iP	12-10-45	Δ(S-P) = 33.8° = 3,755 kms.
		H	eS	12-16-17	H = 12h 03m 59sees
			iS	12-16-26	Depth greater than normal

AN ELECTRONIC SEISMOGRAPHIC RECORDER

F. Keller*

New Kensington, Pa.

For the past three years, an amateur seismographic station has been in operation at New Kensington, Pa., and has recorded practically all of the earthquakes that have been reported by the U. S. Coast & Geodetic Survey. The apparatus in this station is, for the most part, handmade yet it possesses some novel and original features which may be of interest to seismologists.

The novel features are the simplified design of the seismometer, the circuits of the photo-cell pickup and the electronic amplifier, the electrical recorder and the means of obtaining satisfactory voltage regulation to permit the use of A.C. current for illumination and for the amplifier power supply. With the combination of the electro-magnetic seismometer, photo-cell amplifier and electrical recorder that is used, good sensitivity and high magnification are obtained with visible recording on smoked paper without the usual complications and limitations resulting from friction.

The seismometer is of the electric-magnetic type much like the Wenner instrument but it has been simplified in order to eliminate as much machine work as possible. The principal change is in the type of suspension that is used. The upper hinge is a tandem arrangement of two hard brass foil strips; the lower pivot is the usual pivot and jewel cup bearing. The magnetic field is furnished by an extra large Alnico magnet. The seismometer coil is wound with 250 turns of No. 32 enameled wire and has a resistance of 14 ohms. With the proper assembly of the upper hinge, it has been possible to obtain a period of 10 to 15 seconds with very good stability. The design of the instrument is illustrated by Fig. 1.

The seismometer coil is connected to a long period, Type P, L & N galvanometer in a shunt circuit like that used in the Wenner system in

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order to obtain the desired damping ratio. Thus far, the arrangement is conventional and can be employed for the usual method of registration on photographic paper. This type of recording, however, is too expensive and uninteresting for an amateur station. Therefore, an electrical recorder was built which would trace a visible record on a smoked paper chart. This recorder was designed in accordance with the principles outlined by Halley Wolfe[1] with some modifications to provide more convenient and economical operation.

In the recorder described by Wolfe, separate batteries were used for supplying the galvanometer lamp, the photo-cell and the amplifier circuits in order to obtain steady illumination and constant plate and filament voltages. In the present recorder, A.C. current is used for all of the circuits and the galvanometer lamp. This required an entirely different circuit for the electronic amplifier. Moreover, it was necessary to provide some means for overcoming the usual fluctuations in the lamp and amplifier current supply.

Satisfactory regulation was obtained by using a 100 V.A. automatic voltage regulator for supplying the current to the galvanometer lamp and the amplifier and by incorporating a regulated power supply[2] in the amplifier. The latter was necessary to avoid changes in voltage because of the interaction of the various stages of the amplifier circuit. Since the photo-cell and the three stages of the amplifier all draw current from the same power supply, it was found necessary to add a voltage regulator tube between the preamplifier and the phase-inverter stages.

The complete circuits of the amplifier and power supply are shown in Fig. 2. The amplifier contains three separate circuits, namely, a photo-cell and preamplifier, a self-balancing phase inverter circuit[3] and a push-pull amplifier circuit. The amplifier is excited by a beam of light reflected from the mirror of the galvanometer. Thus a frictionless connection is obtained between the seismometer system and the recording system. A shield with a rectangular opening is used in front of the photo-cell. Illumination from the mirror is adjusted so that only about half of the light from the mirror impinges on the cell element. Thus, when the mirror rotates, a smaller or larger area of the sensitized surface of the cell will be illuminated. The output of the photo-cell will vary directly with the area that is illuminated and will cause variations in the output of the amplifier.

The outputs from the plate circuits of the two amplifier tubes are connected to two large coils of the recorder shown in Fig. 3. This recorder has two coils that rotate in a magnetic field; each is wound with 2000 turns of No. 40 D.S.C. wire and has a resistance of about 2000 ohms. The coils are suspended in the field of a large Alnico magnet by means of an 0.025″ dia. nichrome wire and are restrained from lateral movement by ring bearings. The suspension has just enough torque to overcome the friction of the recording stylus on the smoked paper. The stylus is mounted on the end of a 15 inch counterbalanced arm that is attached to the rotating element of the recorder.

When the spot of light is stationary on the photo-cell, the currents in the two coils exert equal and opposite torques; consequently, no deflection of the writing arm will occur. If the spot of light moves, however, as a result of rotation of the mirror, the A.C. currents in the coils will be 180° out of the phase with resultant in-phase torques which will cause the writing arm to deflect. The amount of deflection will be proportional to the amount of rotation of the mirror. Good response to long wave teleseisms is obtained because of the use of large capacity condensers throughout the amplifier circuit.

The various units of the apparatus are installed in a 6 x 12 ft. room in the basement of a residence where they are free from disturbance. The layout of the station is shown by Fig. 4. The seismometer pier goes through an opening in the concrete floor and is anchored to a shale formation about 18 inches below the floor level. The arrangement of the electrical units and accessory equipment is shown by Fig. 5.

Recording is done on a smoked paper chart 8½ x 33″ which is mounted on a 10.2″ diameter drum as shown in Fig. 6. This drum is operated by a 4 Watt electric chart clock and it revolves once every 30 minutes with a chart speed of a little more than one inch per minute. Fastbrite E copy

paper is used for the charts which are fixed by dipping them in an alcohol-shellac mixture. Translation of the drum is obtained with a lead screw that has 8 square threads per inch.

Time is kept by means of a Telechron clock which has a mercury switch connected to the long sweep second hand. This switch actuates a relay that shunts a resistance across one of the plate coils of the recording galvanometer for about two seconds every minute. This causes a slight deflection of the writing arm and registers the time on the record. The clock is checked daily by means of radio time signals.

At present, the seismometer and galvanometer are operated at periods of 10 and 12 seconds respectively. The damping ratio obtained with the shunt resistance is about 0.6. The total magnification of the system is about 500 although a magnification of about 1500 times can be obtained readily. With higher magnifications, however, microseisms become troublesome. The magnification can be changed by several means, as for example, changing the length of the light lever, increasing or decreasing the intensity of the light or by adjustment of the gain control on the preamplifier stage. Only a small amount of light is needed to operate the amplifier. It is obtained from a 6-8 volt radio pilot lamp that is operated at 4-5 volts to obtain long life. A suitable arrangement of lenses gives a spot of light having fairly uniform intensity.

The station has been in operation continuously for three years without replacement of any of the tubes in the circuit. The complete electrical equipment requires about 75 Watts of current for operation. The response and wave form obtained with this system compares very favorably with those obtained with large observatory instruments. Examples of the types of records obtained for nearby and distant earthquakes are shown in Fig. 7. With reasonably well made and adjusted instruments of the type described, it is believed that the visible records will be as good as those made by photographic registration. Furthermore, this system can be used to advantage where photographic methods would not be convenient or economical.

The author is indebted to Mr. Donald C. Bradford, Director of the University of Pittsburgh Seismological Observatory for his interest and help during the design and construction of the station.

REFERENCES

1 Halley Wolfe, "A Seismographic Recorder." *Revue of Scientific Instruments*, Vol. 5, Oct. 1934, p. 359.

2 "Automatic Voltage Regulator." The Radio Amateur's Handbook, 1940, p. 195

3 "A Self-Balancing Phase-Inverter Circuit." R.C.A. Mfg. Co., Application Note No. 97, Sept. 28, 1938.

NEW KENSINGTON SEISMOLOGICAL STATION

New Kensington, Pa.

STATION CONSTANTS AND INSTRUMENTS

Latitude — 40° 33.2′ North

Longitude— 79° 45.2′ West

Elevation — 251 meters above sea level

Lithological foundation—Red Shale—Pennsylvania age.

Instruments

One long period horizontal seismometer of special design connected to a long period galvanometer. Recording is on a smoked paper chart through use of a photo-cell pick-up, electronic amplifier and electrical recorder.

Instrumental Constants

Seismometer period—10 seconds
Galvanometer period—12 seconds
Damping ratio—0.6
Chart speed—one inch per minute.
Orientation—N 15° W — S 15° E
Magnification—500

Time Control

A Telechron clock with a mercury switch and a relay is used. Time marks are recorded directly on chart through amplifier and recorder. The clock is checked daily with radio time signals. Accuracy is within 0.05 minute.

NEW KENSINGTON SEISMOLOGICAL STATION

New Kensington, Pennsylvania

Lat. 40° 33.2′ N. Long. 79° 45.2′ W. Elev. 251 m.

Jan. 20	NW-SE	ePR;	06-33.1		
		eS	06-37.5	3500 Km.	
Jan. 30	Seismic activity starting 06-36.5 U.T.				
Mar. 1	Seismic activity starting 09-52.0				
Mar. 30	Seismic activity starting 07-35.3				
Apr. 14		iP	02-21.5		Lat. 1° S.
		PR_1	02-23.1	4650 Km.	
		iS	02-27.6		Long. 79° W.
		iSR_1	02-30.2		
		L	02-30.9		
May 17	Seismic activity starting 15-27.4				
June 9	Seismic activity starting 11-19.6				
June 21		eP	10-08.0		Lat. 17.7° N
		iPR_1	10-08.6		Long. 101° W
		eS	10-12.7		
July 8	Seismic activity starting 12-45.4				
July 9		i	07-06.4		
		iS	07-15.0		
July 9		i	22-38.5		
July 12		i	05-13.0		
		iS	05-19.1		
		i	05-23.0		
July 29	Seismic activity starting 23-08.7				
Aug. 8		eP	22-43.4		Lat. 14.4° N
		e	22-48.9		Long. 90.9° W
		i	22-50.4	3140 Km.	

GNWCH. DATE	COMPNT.	PHASE	GMT		
Aug. 11	Seismic activity starting 05-00				
Aug. 16		e	19-43.8		
		iS	19-51.5		
Aug. 24	NW-SE	i	22-59.0		
		i	23-07.1	6100 Km.	Lat. 14½° S
	Amplitude so large record could not be read				Long. 75½° W
Aug. 29	Seismic activity starting 12-29.5				
Aug. 29	Seismic activity starting 21-51.0				
Sept. 4	Seismic activity starting 03-10.0				
Sept. 26		i	04-06.2	3200 Km.	Lat. 12.8° N
		i	04-11.0		Long. 87.5° W
Oct. 8	Seismic activity starting 03-15.0				
Oct. 26		i	21-29.7	9250 Km.	Lat. 45° N
					Long. 15.2° E
Oct. 28		P	10-50.8		
		PR_1	10-51.4	3250 Km.	Lat. 15.5° N
		S	10-55.5		Long. 96.4° W
		L	10-59.3		
Nov. 10		P	12-01.0		
		PR_1	12-03.2	14850 Km.	Lat. 35° S
		PR_2	12-06.8		Long. 46.5° E
Nov. 12		e	05-31.3		
		i	05-35.3		
Nov. 12		e	15-34.0		
		e	15-35.7		
		e	15-39.5		
Nov. 25		i	01-23.9		
		i	01-29.0		

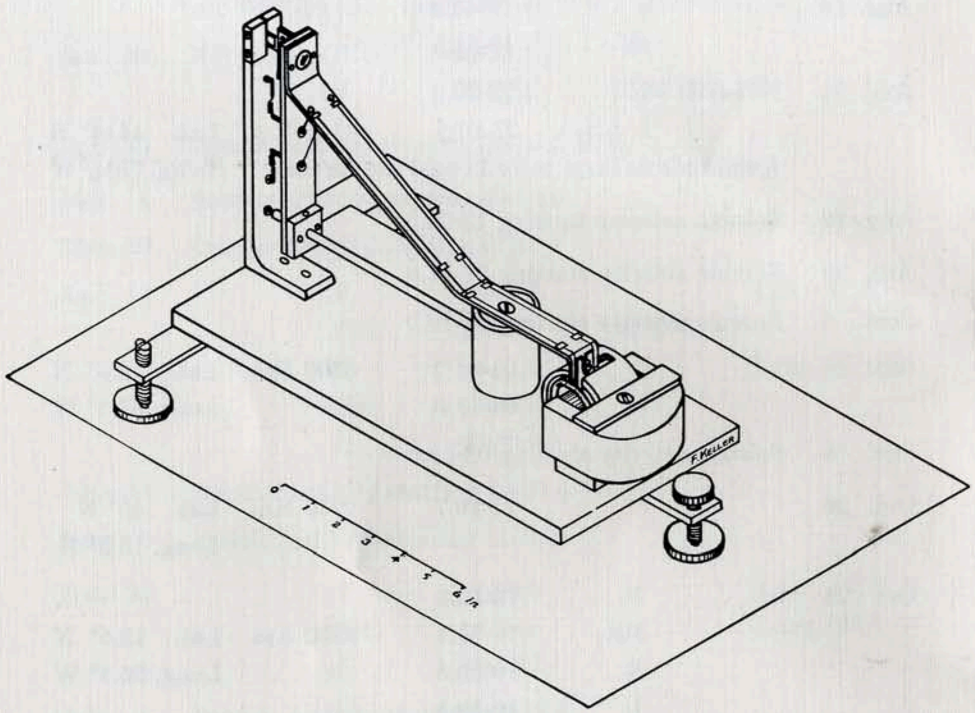


FIGURE I

SHOWS DETAILS OF THE SEISMOMETER.

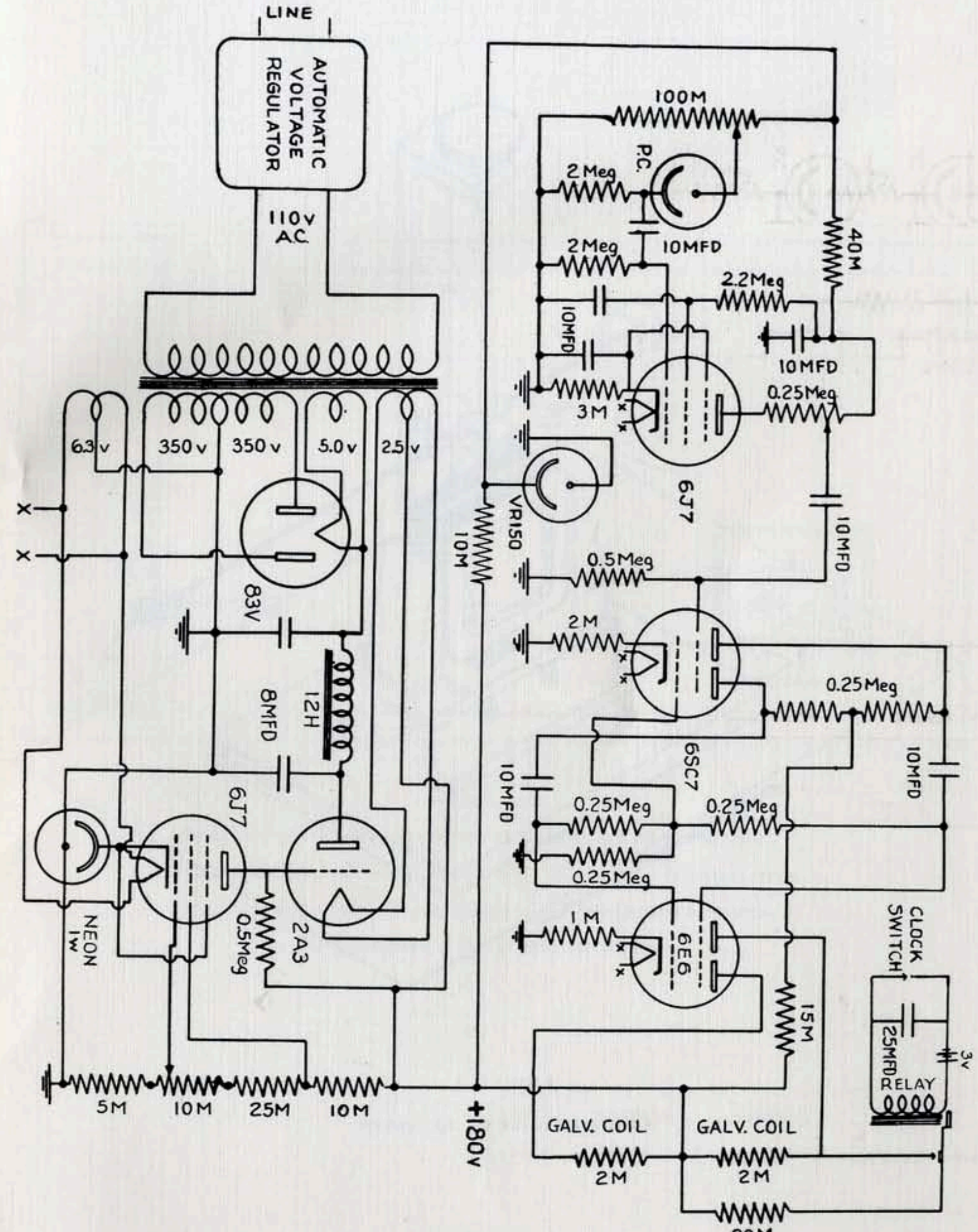


FIGURE 2

WIRING DIAGRAM OF AMPLIFIER AND POWER SUPPLY CIRCUITS.

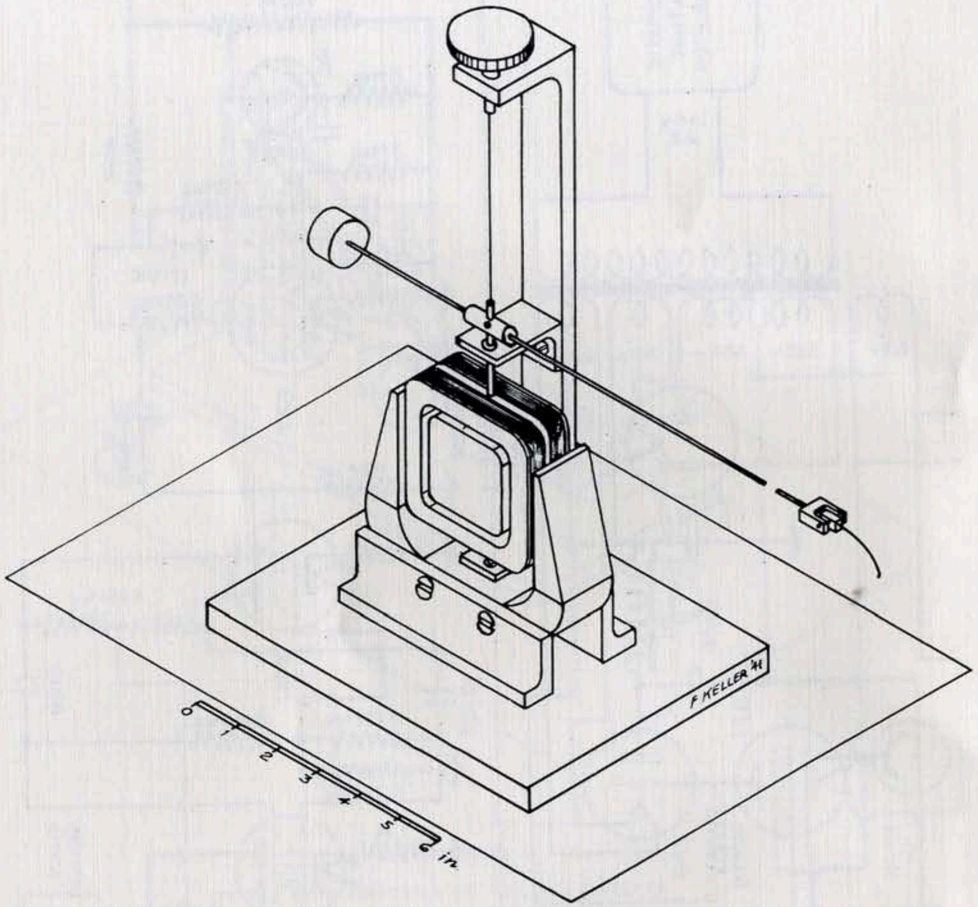


FIGURE 3

SHOWS DETAILS OF RECORDER.

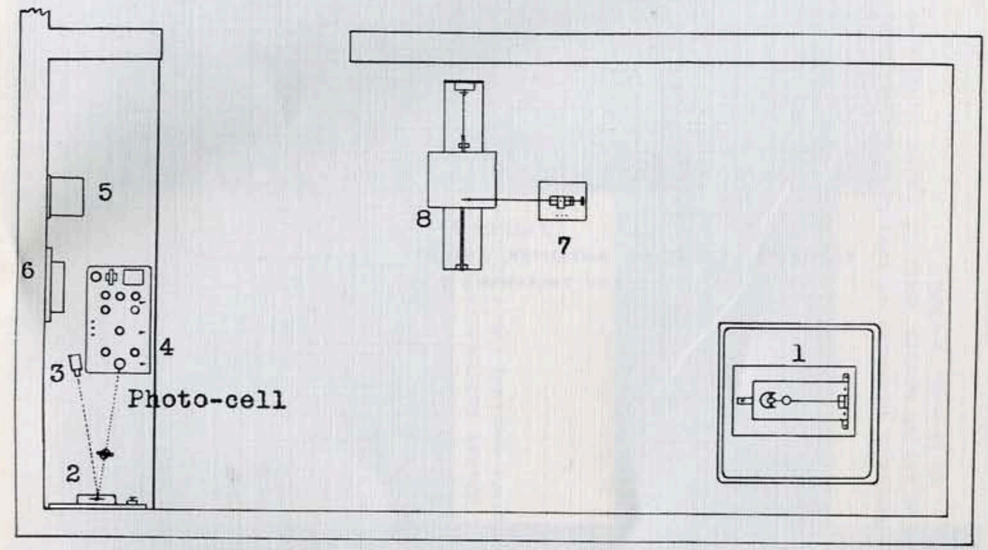


FIGURE 4

SHOWS PLAN OF NEW KENSINGTON SEISMOGRAPHIC STATION.

1—SEISMOMETER. 2—GALVANOMETER. 3—LAMP. 4—AMPLIFIER.
5—AUTOMATIC VOLTAGE REGULATOR. 6—TELECHRON TIMER.
7—RECORDER. 8—RECORDER DRUM.

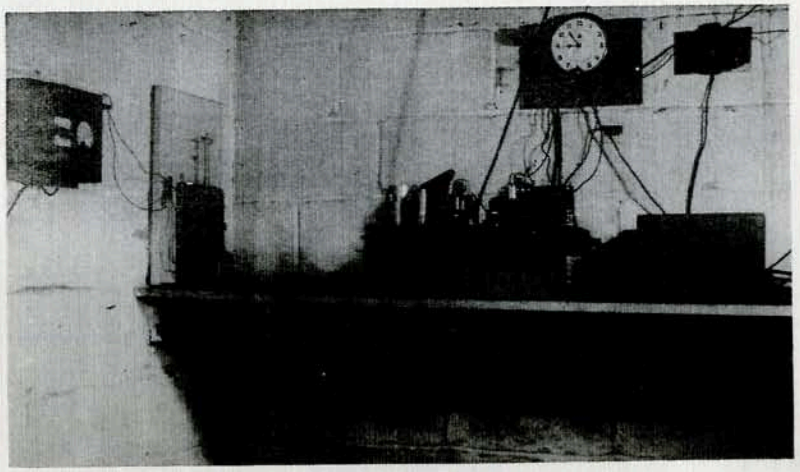


FIGURE 5

SHOWS GALVANOMETER, AMPLIFIER, AUTOMATIC VOLTAGE REGULATOR AND TELECHRON TIMER.

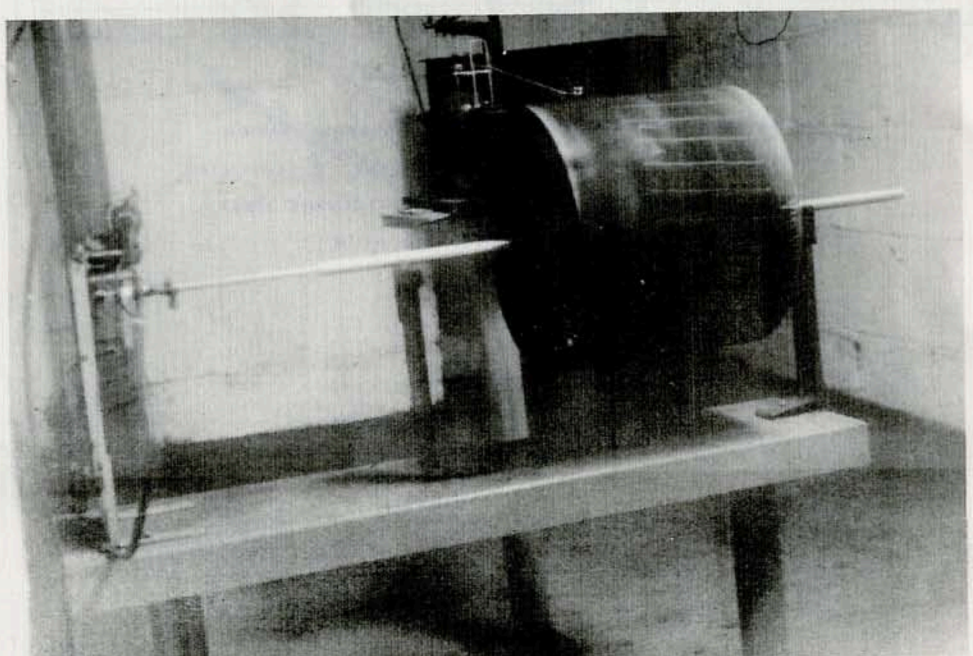
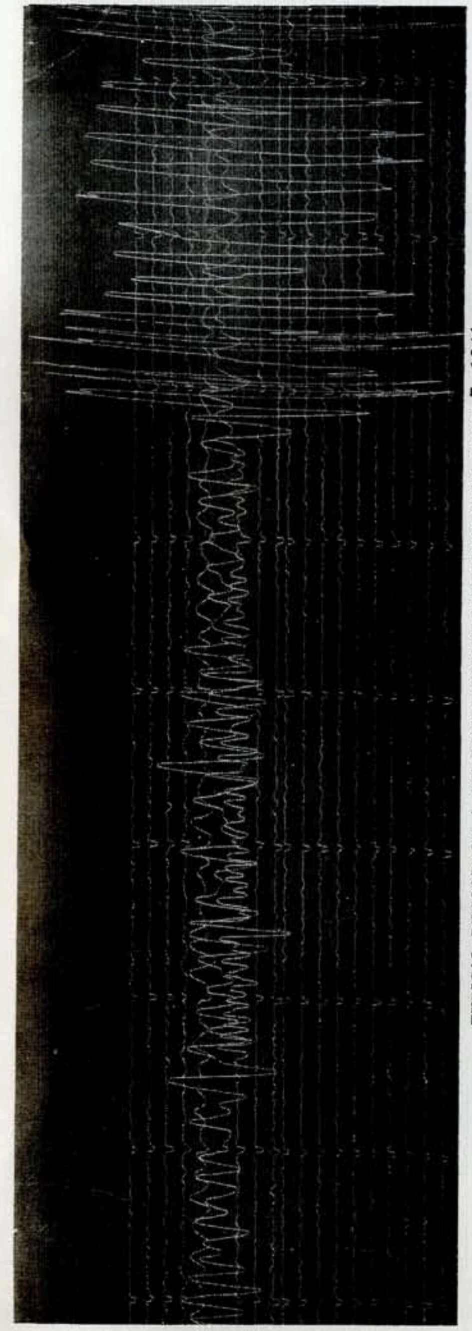
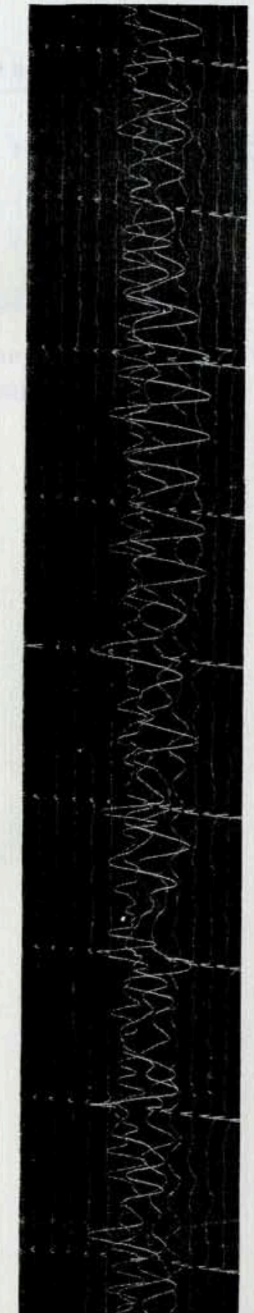


FIGURE 6

SHOWS RECORDER AND THE RECORDER DRUM.



TYPICAL RECORD OF A NEARBY EARTHQUAKE RECORDED APRIL 7, 1941.
EPICENTER NEAR JAMAICA W.I. DISTANCE ABOUT 2800 KM. TO 10 SECS. V 500.



RECORD OF DISTANT EARTHQUAKE RECORDED ON JUNE 6, 1941. EPICENTER NEAR ANDAMAN ISLANDS IN BAY OF BENGEL. DISTANCE ABOUT 16,400 KMS. TO 10 SECS. V—500

FIGURE 7

GNWCH. DATE	COMPNT.	PHASE	GMT
Nov. 26		e	10-47.5
		iS	10-55.2
Dec. 5	Seismic activity starting 14-47.5		
Dec. 20	Seismic activity around 14 00 with large surface waves. Most of record unreadable because of abnormal micro-seismic activity.		