29. *Seven-Channel Triggered Magnetic Tape Recorder for Routine Seismic Observations.*

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1. Introduction

A new equipment for recording earthquake motions by means of a magnetic tape recorder named MATS-1 was completed some four years ago. Since then routine seismic observations by means of this tape recorder equipment has been made continuously with success and fairly satisfactory records of earthquakes have been accumulated.

As will be seen in the previous paper[1)] the equipment then constructed was a machine having only one component. Needless to say it is preferable, or even necessary, to have a three-component seismograph for recording a complete set of seismic signals. And the first type recorder seismograph MATS-1 was not very satisfactory in that it had only one channel. We were anxious to have a multi-channelled seismograph of a magnetic tape recorder system. By the benefit of the institutional research fund awarded to our Institute by the Ministry of Education, we were able to have a chance to construct multi-channelled one. A seven-channel magnetic tape recorder seismograph MATS-2 for routine use was constructed and put in operation recently. The characteristics of this machine will be described here somewhat in detail.

2. General construction of the equipment

In order to make the explanation simple the construction and the works of the respective unit devices are concentrated in Table I and illustrated schematically in the block diagram in Fig. 1. The appearance of the whole equipment is shown in Fig. 2.

Ground vibrations due to seismic shocks are converted into a signal voltage through a seismometer and the signal voltage is connected to the

1) S. OMOTE, S. MIYAMURA and Y. YAMAZAKI, *Bull. Earthq. Res. Inst.*, **33** (1955), 397.

Table I. Constructions and works of each unit.

Unit	Electric power controller	Preamplifier	Direct-coupled amplifier	Modulation unit	Demodulation unit
Construction	1. AC100-volt switch. 2. Cut-off relay for main power. 3. Alarm circuit in the case of emergency.	1. 12AX7. 2. Connection tester of the seismometer line. 3. Input tester terminal.	1. 12AT7, 12AX7.	1. 6J6, 12AU7.	1. 12AX7, 6AU6, 12AU7×2.
Works	1. On and off of the main power line. 2. Automatic cut-off of the main power line when (1) the tape is broken, (2) some troubles took place in any part of the power unit, (3) the voltage of the power line dropped below 80 volts.	Amplification of output voltage from a seismometer.	Amplification of output voltage from the preamplifier.	Pulse width modulation. Carrier frequency is 800 cps. Fluctuation is less than 0.8 cps.	Demodulation of the modulated seismic signal.
Channel	1	7	7	7	7
Type		CR-coupled low frequency amplification.	Cascode type connection.	Pulse width modulated system.	
Gain		28 db.	37 db.	Maximum modulation is attained at 80% of total width	90 db.
Input		Non-distortion range 50 μV–1.3 mV at the full gain (10 cps).	±D.C. 30 mV. (maximum)	±D.C. 7.0 V.	235 μV.
Output current		±D.C. 50 μA–1.3 mA.	±D.C. 0.51 mA.	±D.C. 0.7 mA.	±D.C. 0.78 mA.
Remarks					

Unit	Amplifier for preservation magnetic tape recorder	Regulator unit for recordings	Oscillograph	Magnetic tape recorder with loop tape	Preservation tape recorder
Construction	1. 12AU7, ½12AU7.	1. Trigger circuit. 2. Delay circuit for recording time regulation. 3. Counter. 4. Test button.	1. Galvanometer, 100 cps. 2. recording camera. 3. Tuning fork 100 cps.	1. Recording heads of 4 traces; 2 banks. 2. Play back heads of 4 traces; 2 banks. 3. Erasing head connected with 30 KC oscillator. (5Y3, 6V2×2) 4. Contact relay that alarms tape break.	1–3, The same to the left column.
Works	Applies the pulse width modulated signals on to the recording head of the preservation magnetic tape recorder.	1. To make start the recording motors. 2. To regulate the time during which the recording are performed. 3. To indicate the number of recorded earthquakes. 4. To monitor the works of the every parts.	Photographed on a bromide paper.	1. Recording. 2. Playing back. 3. Erasing.	1. Recording.
Channel	7	1	13	1	1
Type	CR-coupled amplification.	C-R coupled low freq. amplification Delay circuit by charge and discharge system.	Electromagnetic damping.	Tape width; 1/2 inch endless tape; speed 7.5 in/sec. Wow less than 0.3%.	Wind up system.
Gain	20 db (variable).	80 db (variable).	5.5×10^{-5} A/mm.		
Input	3.5 V			Input to the recording head is 14.0 V.	
Output	14.0 V	AC 100 V		Output from the play back head is 235 μV. Tape noise; ca.50 μV.	
Remarks			paper speed; 30 mm/sec.	S/N; 38–40 db.	

input of the preamplifier. From there it is led to the main amplifier before reaching the modulation unit. The square waves of a symmetric

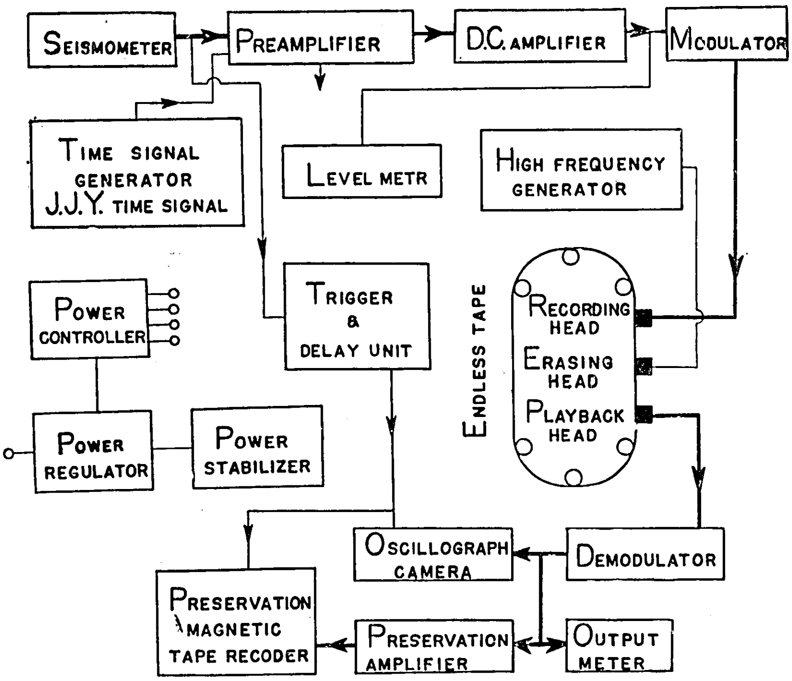

Fig. 1. Block diagrams of the equipment.

type generated by a pulse generator with a frequency of 800 cps are used as carrier waves for modulation. When modulation takes place the width of the pulse of the square carrier waves is changed by the output from the main amplifier which is connected to the original seismic signals, in such a way as the positive information signal causes the positive current pulses to decrease, and likewise the negative information signal causes the negative current pulses to decrease. The amount of change in width depends upon the amplitude of the seismic signal, a large amplitude signal causing the width to vary greatly. When the high frequency information signal is applied the width of the pulses is changed at a high rate of repetition depending upon the modulation frequency, the time rate of changing of the pulse width is regulated by the frequency of the input waves.

This pulse width modulated seismic signal is subjected to additional stages of gain, and then connected to the recording head, where it is recorded on the magnetic tape running with the constant speed of 7.5 inches per second. The tape is endless, i.e. in loop form. The seismic signal recorded on the tape reaches the playback head 40 seconds later after having passed over the recording head. The output voltage taken out of the playback head is divided into two. One part is lead to the oscillograph after passing through the demodulator, where the pulse width modulated seismic signal is demodulated into the original signal of low frequency. These low frequency seismic waves cause the galvanometer in the recording oscillograph to vibrate and the seismic curves are photographed on the bromide paper. The other part of the output voltage from the playback head is led to the recording head of the preservation magnetic tape recorder after passing through an amplifier, and here seismic waves are recorded on the magnetized tape. The erasing head is placed immediately before the recording head so that all the information recorded on the tape will be erased completely and the tape supplied to the recording head will always be a clean one. The erasing is effected by the high frequency current of 30 KC applied to the erasing head. In this way the endless tape goes round continuously.

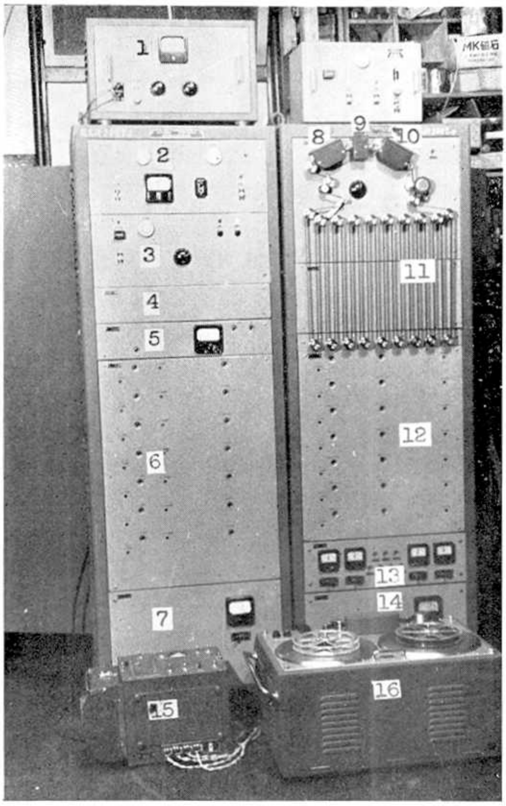

Fig. 2. 1. Preamplifier. 2. Power controller 3. Recording time controller. 4. Trigger unit. 5. Level meter. 6. D.C. Amplifier and modulator. 7. Power unit. 8. Playback head. 9. Erasing head. 10. Recording head. 11. Endless tape. 12. Demodulator. 13. Output meter. 14. Power unit. 15. Recording oscillograph. 16. Preservation magnetic tape recorder.

Besides these devices several additional units are necessary, including a trigger circuit which makes start the recording oscillograph and the preservation magnetic tape recorder as soon as earthquake motions arrived at the place where the seismometers are installed. There is also a reset circuit in order to stop the operation of the oscillograph and the preservation tape recorder when the seismic vibration of the ground has died away and then to reset everything for the next recording. Some other accessories are also attached, such as time-marking devices for the accurate commencement time of the earthquake motions, stabilization circuits for the power supply, a level meter to indicate input level, a counter device that announces the number of earthquakes registered on the recording equipments, an alarm device that announces the occurrence of troubles in any part of the equipments, and the relay mechanism that cuts off the power source in the case of emergency.

3. Details of the unit devices

a) *Preamplifier*. The seismic signal is taken from a seismometer and connected to the input of the preamplifier. From there it goes on to the direct-coupled amplifier. In the preamplifier two stages of the CR-coupled system are employed. The gain of the two amplifier stages is changeable, the maximum being 28 db. The tubes used are 12AX7. The amplification looks rather low considering the large number of the tubes used. This is due to the fact that the amplified voltage is lowered to 50 : 1 at the last stage in order to make it match better with the impedance of the direct-coupled amplifier.

In the pannel of the preamplifier there are also housed the test terminals used for adjusting the amplification and the tester circuit that checks the continuation of seismometer lines.

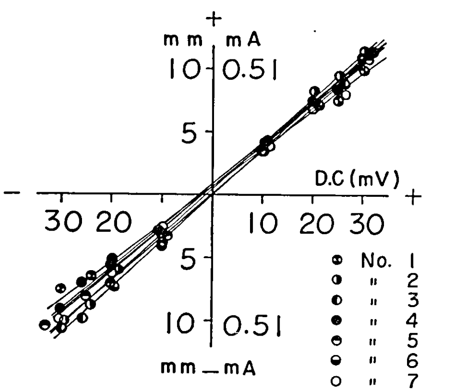

Fig. 3. Characteristic curves of direct-coupled amplifier, that indicate input voltage and output current relations.

b) *Direct-coupled amplifier*. The second unit is a direct-coupled amplifier. For the purpose of getting a good signal-to-noise ratio a Cascord system is employed. The maximum gain obtainable is as high as 37 db. The output signals from the preamplifier are amplified by a tube 12AT7 (V_1). The voltage due to R–8 is applied to the first grid of

12AX7 (V_2), by which the amplitudes of the pulse voltage generated in the R12 are regulated. The gain of the D.C. amplifier fluctuates with the fluctuations of the line voltages of the power line. This disadvantage, however, in practice only slightly affects the gain of the diret-coupled amplifier, provided the commercial 100-volt AC current is well stabilized. The characterstic curves of the direct-coupled amplifier units are shown in Fig. 3 with respect to each of the seven channels.

c) *Modulator*. As is well known the frequency of earthquake waves is so extraordinarily low that signal voltages from the seismometer will not be recorded directly on the magnetic tape. In order to overcome this difficulty a modulation system is introduced. In the former equipment a frequency modulated system was employed, while, in the present equipment the pulse width modulated system (PWM) was employed. The PWM has advantages over other types of modulation system in that:

(1) It works in good stability.
(2) Electric circuits are simple.
(3) The tape speed needs not be held so uniform as in the FM system.

However, it also has disadvantages in that: (1) the connecting part of the loop magnetic tape leaves a distinct mark on the seismic record and (2) a somewhat higher tape speed is required than that of other modulation system. As long as the FM system is employed, the fluctuation of 0.5% in the tape speed produces the change of cycles by 2–3% in the carrier waves of 800 cps. Namely, in the FM system the output is directry proportional to the velocity of the recording medium such as tape, so the tape velocity must be kept at a strictly uniform rate in order to have a good signal-to-noise ratio. In the case of PWM no such strict uniformity in the tape velocity is demanded.

In a pulse width modulated system, as in the other types of modulation, the fluctuation in the center frequency of the carrier waves presents a serious problem with respect to the accuracy of the recorded seismic signals. In our equipment, however, this fluctuation is successfully reduced to as low as 0.1%. The tape speed, from all these considerations, was determined to be as 7.5 inches per second.

As will be seen in the circuit diagrams in Figs. 4–a and b, the output voltage of the 800 cps generated by the Hartlay oscillator is amplified beyound its saturation point and is clipped. It then passes to the differentiation transformer where the pulses are differentiated. These differentiated pulses are fed in parallel to the second grid of 12AX7 (V_2) of the respective modulation units of the seven channels. In such a man-

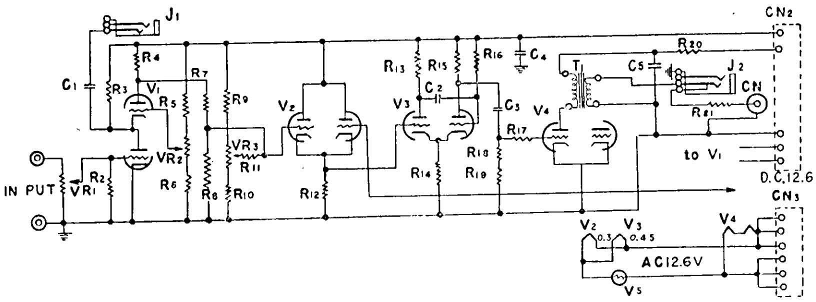

Fig. 4-a. Circuit diagrams of amplifier and modulator.

ner the carrier waves of a regular square form generated in the respective modulation units of the seven channels are controlled by a single source of pulses.

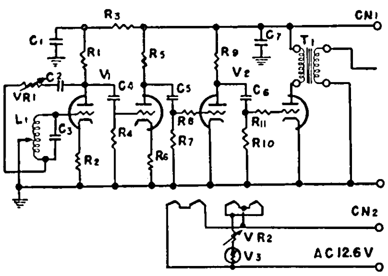

Fig. 4-b. Circuit diagram of pulse generator.

The differentiated pulses fed to the second grid of 12AX7 (V_2) are here mixed with the seismic signal from the output of the D.C. amplifier. The pulse voltage drops between the two ends of the resistor R12 regulate the tube 6J6 (V_3) and the voltage of the square wave type in 800 cps is formed between the two ends of the resistances, R18-R19.

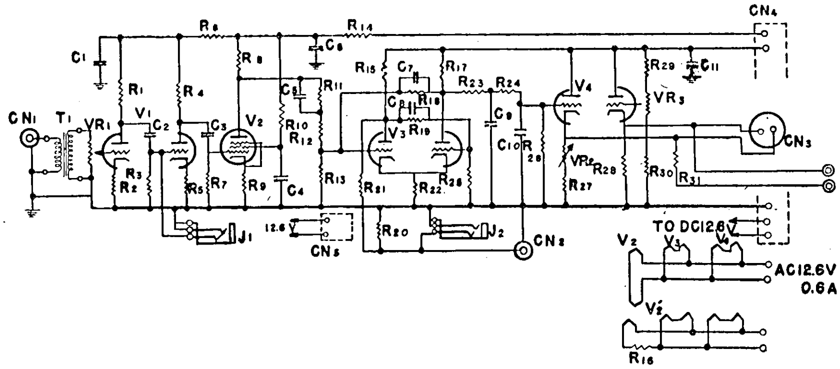

Fig. 4-c. Circuit diagram of demodulator.

Then the pulse-width modulated signals are amplified in their current through the left hand side of the 12AU7 (V_4). These pulses of current are coupled to the recording head through the output transformer connected to the plate of 12AU7 (V_4). The maximum amplitude to be recorded without any distortion modulates the width of the pulse to the depth of 80% of the original width. The non-distortion input voltage to be modulated is 1.2 mV at 10 cps with the full gain of the preamplifier. Modulation and demodulation characteristic curve of a channel is depicted in Fig. 5. In the figure input voltage to the first grid of the direct-coupled amplifier is related to the output current from the demodulator. In preparing the figure the output from the modulator is directly connected to the input of the demodulator, skipping over the units including the magnetic heads and magnetic tape.

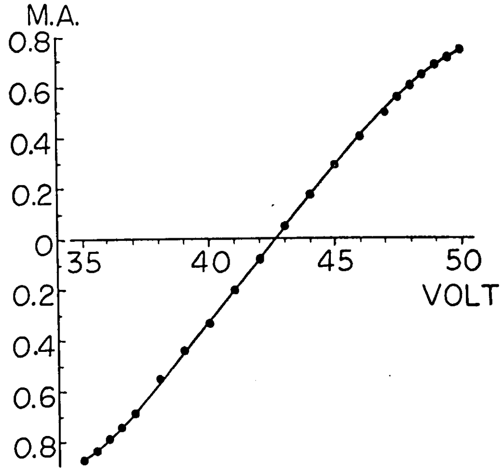

Fig. 5. Modulation and demodulation characteristic curve of a channel. Abssissa in a input voltage to a modulator. Ordinate is the output current from a demodulator. (In this figure the modulator and the demodulator are connected directly, without passing through the magnetic tape.)

d) *Head assembly.* As to the recording head, seven-track units have been designed for a 1/2 inch tape. Two banks of heads are used with four heads per bank, which gives the total number of seven information channels, as the fourth head of the second bank is not used for recording. In order to minimize the cross-talk between the heads, the tracks of the four heads of the second bank are made to fit in the gaps between the tracks of the four heads of the first bank. The seven playback heads are arranged in the same way as the recording heads, namely, they consist of two banks of four heads each and the distance between the two banks of playback heads is adjusted to be the same as that between the recording heads as far as is possible. In practice, however, there is apt to remain some slight difference between the two distances of the respective two banks. This difference, however, can be calibrated very accurately beforehand so that no errors will result from the arrangement of the banks in calculating the commencement time of seismic signals. The background noise due to the magnetic tape tends to be loud at the tracks on the extreme outer sides of the tape. However, as will be seen in Fig. 10, the tape noise due to the extreme outer tracks disturbs the seismic records only slightly. The impedances of the recording and playback heads are 50 ohms at 1000 cps.

As in ordinary recording, the current passing through the magnetic recording heads causes a magnetic field to be produced in the gap of the head. As the tape moves over the head and the current is alternately reversed according to the modulated pulses applied to the head, small bar magnets will be arranged into the tape in regular directions according to the sense of current that passes through the head, and thus small magnets are energized into the recording tape.

e) *Demodulation.* As the tape is again run over the heads, after it has passed over the recording heads, the magnets which have been energized into the tape at the recording head cause an electric current to flow in the circuit of playback head. This current is then coupled to the input transformer of the demodulator. The secondary of the transformer is connected to the grid of 12AX7 (V_1) and then passes into the 6AU6 (V_2).

In this process, the weak current of blunt square waves from the playback head, being amplified and clipped, becomes free from the wave distortion, and reproduces the same current pulses which are applied to the magnetic recording heads. The gain of the amplifier of this part must be made very large, say 90 db, since the output current from the playback head is very small. In the next stage, as will be seen in the demodulation wiring diagram in Fig. 4-c, these modulated seismic signals are put into the resistance-condenser differentiator. The output signal from this differentiator is than applied to the bistable multivibrator. The signal is then applied to a filter, by which the 800 cps pulses are filtered out; the residue is the original seismic signal. The demodulated and reproduced seismic signal is then applied to a galvanometer of the recording oscillograph.

As has been mentioned, the demodulation circuit is designed to create a high gain so that specially designed shieldings are needed on the input transformer of the unit in order to prevent the ham inductions from outside. For the purpose of checking, there is a jack on each channel leading to a cathode-ray oscillograph, provided it is desired to have a monitor of the output waveforms from the demodulator.

f) *Recording oscillograph.* The demodulated low frequency seismic signals are led to a recording oscillograph of 13 channels. The frequency and the sensitivity of the galvanometer used are 100 cps and 5.5×10^{-5} A/mm respectively. The electric motor that drives the bromide paper in the recording camera is triggered by the seismic pulse and the camera records the seismic signals on the photographic paper. Six of the 13 channels of the oscillograph record the delayed seismic signals mentioned above, one records the JJY time signals that also have passed through the magnetic head. One records that division of the seismic signals from the output of one of the seismometers which did not pass through the magnetic head. This channel is intended for checking the distortion due to the magnetic delay devices. The remaining five channels are for time signals, the explanation of which will be given later.

g) *Preservation magnetic tape recorder.* The seismic signals energized into the magnetic tape at the recording head go through the playback head and a moment later pass onto the erasing head, where the seismic signals in the tape are erased completely prior to their reaching the recording head again, as the tape is in a loop form. By this mechanism the recording head is always supplied with a clean tape. In order to have the seismic signals permanently in the form of recorded magnetic tape it is necessary to have another magnetic tape recoder machine exclusively for the preservation of magnetic tape.

As already stated in the preceding paragraph (e), after the seismic signals are taken out of the playback head and freed from wave distortions, a part of the current pulse of modulated waves are shunted to the amplifier circuit for the preservation magnetic tape recorder unit. The amplified current of the pulse width modulated seismic signals are then applied to the recording head of the preservation unit.

The mechanism by which the recording is made on a preservation magnetic tape is the same as that of the recording part of the endless tape. In this part too an erasing head is placed directly before the recording one. The driving mechanism of the preservation tape is the wind-up system, not the endless system. In this case too special care must be taken for the geometrical configurations of the relative position of the two banks of magnetic heads. In practice, careful calibrations on the time difference of the two different banks will eliminate any remarkable error in the reading of the seismic phases. The operation of this part is controlled in the same way as with the recording oscillograph. The starting of the winding up of the tape reel is triggered by the seismic pulse, and its stopping is effected by the function of the control unit.

h) *Delay unit*. The memorizing capacity, one of the greatest advantages of the magnetic tape recorder seismograph, is attained by the recording of seismic signals on the magnetic tape. The length of the time during which the memory capacity will last is controlled by the delay unit. In this delay unit the delay time is given by the running time of the tape from the recording head to the playback head. In the former equipment, MATS-1, there was a special storing box of magnetic tape prepared for the purpose of giving a long delay time. In the present equipment, however, on the one hand, the tape is twice as broad as the former one and, on the other hand, the tape speed too is twice as fast as that of the former one, so that the storing box is no longer applicable. For the purpose of elongating the running course of the endless tape, as will be seen in Fig. 2, a simpler but surer mechanism consisting of twelve rollers is employed. By this mechanism we can have the delay time of forty seconds successfully. In such a mechanism the rotation friction of the rollers must be made extremely small in order to have the tape run smoothly.

There may be varying opinions as to what is the proper length of the delay time. The driving of the motor of the recording camera of the oscillograph and of that of the preservation magnetic recoder, reaches its full force less than a few seconds after the trigger circuit is closed. The delay time might be made very short, provided the trigger starts exactly at the beginning of the P waves of seismic signals. However, as is well known, the beginning of the P is in some cases so small in amplitude that if we adjust the trigger level so high as to be sensitive enough to catch it, a false start may frequently be caused by the ground noises that are so common especially in large cities. In order to avoid this confusion it would be safe so to design the trigger circuit that it will start at the beginning of the large S phase. For this reason the delay time should be made longer than the P–S time of the earthquakes to be recorded. In designing this equipment we at first aimed at recording near-by earthquakes and chose a delay time of about 40 seconds. It will not be difficult to elongate the delay time by more than 50% by adjusting the locations of one or two rollers.

i) *Control unit*.

(i) Trigger amplifier. The input voltage to the trigger amplifier is derived from a seismometer installed side by side with the recording seismometers. As soon as the input voltage from the trigger seismometer exceeds some definit level, a pulse is sent out from this amplifier (Fig. 6).

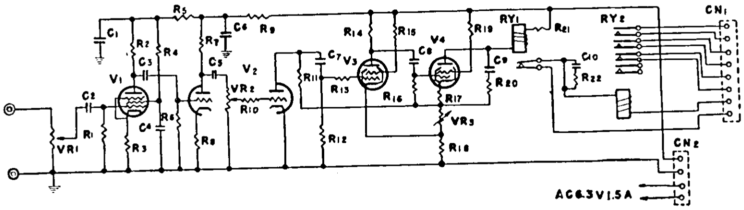

Fig. 6. Trigger circuit diagram.

In order to avoid the false starting due to ground noises the trigger level is carefully adjusted. With respect to the seismometer used, the input level that makes the trigger start is adjusted at about 3 mV, at 10 cps, namely, 0.5 gals at 10 cps of ground accelerations (Fig. 7). The electric pulse issuing from the trigger amplifier puts the following circuits into action : (1) It makes the electric circuit of the motor that drives the recording camera of the oscillograph close. (2) It makes the circuit of the driving unit of the preservation magnetic recorder close. (3) It makes the electric circuit of the recording time controller close. (4) It makes the counter and alarm circuits close.

(ii) Recording time controller circuit. This unit controls the time during which the recording camera and the preservation magnetic tape recorder are in full operation. The output pulse from the trigger amplifier makes start the delay circuit consisting of the tubes, the circuits consisting of the mechanical relays, and the combinations of these circuits, and as a result of such operation the driving of the motors of the camera and of the tape recorder are made to stop automatically. The operation time is adjusted at 1, 2, 3 and 4 minutes respectively. As soon as the recording is completed the whole equipment is reset for the next recording.

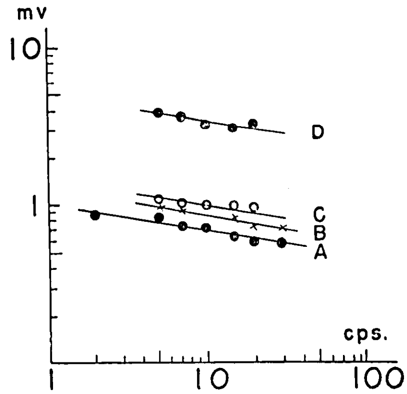

Fig. 7. Diagram indicating the trigger level. Indicator points the graduation D; No. 4, C; No. 6, B; No. 8, A; No. 10 (maximum sensitivity).

(iii) Auxiliary devices. Besides these units mentioned above, some auxiliary devices such as the counter for the number of recorded earthquakes and other indicators such as the level meter are also contained in the controller parts (Nos. 2 and 3 in Fig. 2).

j) *Time marker circuit.* Two kinds of time-marking devices are employed. One is the system relying on the JJY time signals fixed directly on the seventh channel of the tape-recording head. As will be seen in the photographic record in Fig. 10, the JJY time signal is recorded on the fifth line of the 13 channels. By correlating this time signal line with the lines of seismic waves recorded side by side on the same paper, it is easy to have the accurate commencement time of the recorded earthquake with reference to the second. There is no knowing, however, what minute and what hour of the day this second mark or even the minute mark due to the JJY time signal left on the record represents, since it is only for three or four minutes that seismic recordings usually last. For the purpose of giving the standard minute and hour of the day on record, a standard clock is employed which sends out special signals of seconds, minutes, and even hours unceasingly, marking the hour and minute of the day. These marks are recorded through the 1st, 2nd, 3rd and 4th channels of the galvanometers of the recording oscillograph, and, at the same time, to give a good and accurate comparison with the time mark of JJY, a part of this special time signals is superposed to the JJY time mark on the seventh channel of the magnetic recording head.

k) *Power supply.* The MATS-2 type magnetic tape recorder equipment is constructed for use in the routine observation of earthquakes, so that the power of the equipment needs to be supplied entirely from the commercial AC 100-volt 50 cps, for otherwise it would be very inconvenient. We were able to overcome successfully every disadvantage originating from the use of the AC 100-volt, such as fluctuations of the voltage of the source power, the residual ripples which are apt to remain on the rectified heater current of the tubes etc. by some means or other.

When the main switch of the power supply is closed artificially, all the circuits are closed one by one automatically in due order and all the conditions are automatically fulfilled for the next recording of seismic signals, as long as the power is supplied. These processes are shown in Table I.

4. Overall characteristics

Overall performance characteristics of the pulse-width modulated magnetic tape recorder are illustrated in Figs. 8a and b. When a known sinusoidal voltage of a constant frequency from a test oscillator is applied to an input of the preamplifier of one of the channels, it passes through "amplifier—modulator—recording head—magnetic tape—playback head—demodulator—oscillograph" and then it is recorded photographically in a form of sinusoidal waves. In Fig. 8-a is shown the relation between the input voltage and the recorded amplitude of the sinusoidal waves with respect to different frequencies. From this figure we see that the difference in the frequencies exerts little effect on the output amplitude within the range from 14 to 50 cps, while for higher frequencies it appears that the sensitivity begins to decrease. With respect to any other of the seven channels, as will be seen in Fig. 8-b, a like curve is to be obtained.

Then in the next place has been studied the relation between the input current and the amplitude of the final output current, with the frequency of the input signals fixed at a definite cycle say 14 cps. The relation has been studied with each of the seven channels, with the result illustrated in Fig. 9. From the figure it is seen that there is

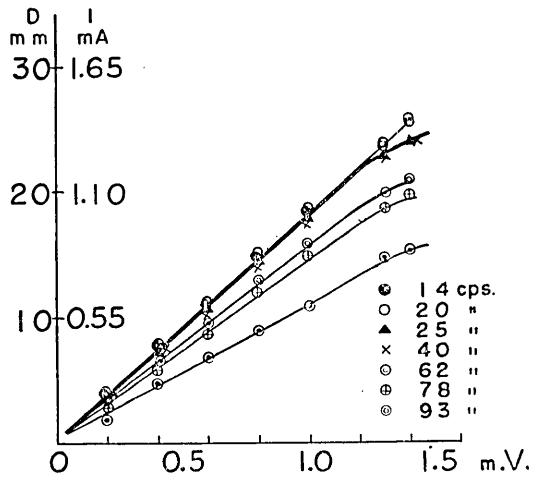

Fig. 8-a. The relation between the input voltage and the recorded amplitude with respect to different frequencies.

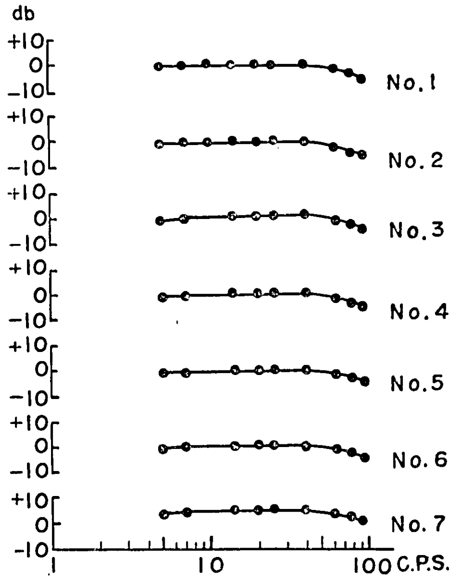

Fig. 8-b. Over-all frequency characteristics.

some difference 20% at the maximum, in the sensitivity of the seven channels. This difference, however, seems to originate not from any system of the magnetic tape recorder, namely modulation, magnetic tape, or demodulation parts, but from the difference of sensitivity or of frequency characteristics of galvanometers.

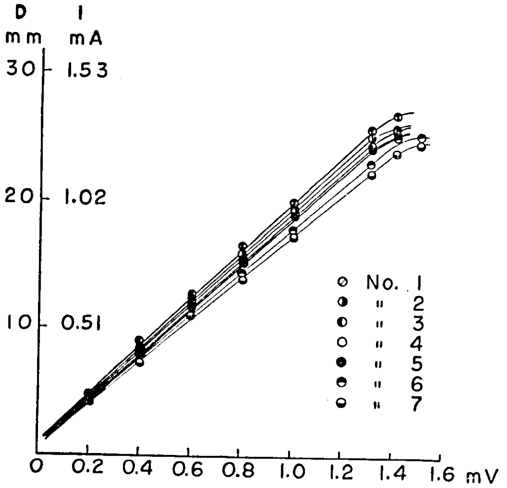

Fig. 9. Relation between the input voltage and the recorded amplitude of different channels at a fixed cycle, 14 cps.

As the examples, the records of a test oscillator and of ground noises photographed on a bromide paper are reproduced respectively in Fig. 10 a, b, as the final product of the magnetic rape recorder equipment. In preparing the records, the output voltage from a test oscillator and a seismometer due to ground noises were applied in parallel to the inputs of the preamplifier of the seven channels, and then the input signals were passed through every unit of tape recorder devices including the magnetic tape, and finally they were photographed on the bromide papers.

With this equipment MATS-2 here described, a very low wow was achieved by introducing the PWM system. The wow was reduced as low as 0.3%, but the tape noise was somewhat larger than in the case of the former type MATS-1, in which a FM system was employed. In this case the tape noise had an amplitude of ± 0.5 mm on the photographic record at the highest gain of the amplifier. In future, we hope to reduce the tape noise further by making the tape speed twice as fast as the present one and by improving the configuration of the recording heads.

5. Concluding remarks

In 1955 our Institute was awarded an Institutional Research Fund by the Ministry of Education for the construction of the Tele-recording Seismic Observation Equipment. The MATS-2 magnetic tape recorder seismograph described in this paper has been constructed as a recording part of the said equipment. The wireless part was constructed by

Miyamura and others[2] as reported in the preceding Bulletin.

By means of this MATS-2 the behaviour of the ground vibration due to seismic shocks is now recorded through six seismometers. The seismometers are now installed so as to register the earth movement in terms of three components at two different locations.

The photographic record to be obtained by the MATS-2 has a great advantage over other types of seismic records in that the paper speed is more than ten times as fast as in ordinary types of seismometers, while the consumption of bromide paper is only as little as one-tenth or even one-hundredth of the amount consumed on other typed.

The seismic signal recorded on tape will be of unlimited usefulness. It is permanently available in the same live electrical form in which it was recorded. A played-back record coupled with a filtering circuit will be especially advantageous for the further analysis of seismic waves. Moreover the reproducible seismic signals recorded on a magnetic tape will be found ready for repeated analyses by whatever new analytical techniques that may be evolved in future.

6. Acknowledgement

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2) S. MIYAMURA and M. TSUJIURA, *Bull. Earthq. Res. Inst.*, **35** (1957), 381.

29. 磁気テープ利用遅延記録方式による 7 素子地震動常時観測装置

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磁気録音テープを利用する遅延記録方式地震動常時観測装置はすでに数年前に試作せられ，今日迄観測がつづけられてきた．しかしこの時は 1 成分のみの記録装置であつたために実際の地震観測装置としては極めて不充分なものであつた．今回機会を得て 7 素子による磁気テープ遅延記録方式による地震動常時観測装置を完成したのでここにその概略を報告した．本機の構成は第 1 図の blockdiagram 及び第 I 表に見る通りである．前回のものとくらべ改良された主な点は (1) channel 数を 7 とした．(2) channel の数が増加したのでテープ幅を 1/2 吋とした．(3) 前回には変調方式として周波数変調を用いたが今回はパルス幅変調をとりいれることとした．(4) テープ送り速度を 7.5 吋/秒 と前回より早くした．(5) 刻時装置を改良し正確な発震時が記録せられるようにした．等である．テープの幅が大きくなり，又 speed も早くなつたので遅延時間を長くすることには困難が伴つた．前回のように箱の内にためる方式は利用できなくなつたので沢山のローラーを用い，テープの走行距離を延長させるようにした．現在は遅延時間 40 秒で運転されているが，この機構でも 1 分位迄遅延時間を延長することは容易である．

常時観測を目標とするので電源には全て 100 volt 交流を利用している．従つて電源電圧の変動等により妨害せられないよう充分注意して構成されているばかりでなく，運転中に発生するかも知れない種々の故障に対してはそれぞれ警報又は自動停止装置が働作するようになされている．

録音ヘッド相互の cross-talk はほとんど認められない． PWM を採用したのでテープ回転ムラによる影響もきわめて少ない．しかし全体として tape noise による影響は前回の 1 成分のものより少し大きいようである．

本機は完成してからまだ日が浅いが故障なく観測がつづけられている．

オシログラフに記録される地震動の paper-speed は 30 mm/sec であるので地震動の解析には大きな利用が期待される． paper-speed が早いにもかかわらず記録が遅延方式であるのでブロマイド紙の消費は極めて少なくてすむのも本機の大きな特徴の 1 つである．なお，テープとして保存される地震動記録は今後ますます利用の途がひらかれることと期待せられる．

昭和 30 年文部省機関研究費として本所に「無線式無人地震計による精密地震観測法の研究」の費用が交附せられた．この研究において無線搬送による地震動電送部分は宮村その他により研究が行われ，すでに本所彙報に報告せられている．本機はこの機関研究の記録部分として製作せられたものである．

本装置の開発にあたつては東京通信工業株式会社の労力に負うところが多いので特にしるして感謝の意を表したい．また本所宮村助教授からあたえられた援助に対して厚く感謝する．本機の経費は文部省機関研究費に負うものであり，当局に厚く感謝の意を表したい．なお，本機関研究を遂行するにあたり有益な助言をあたへられた東京大学工学部西村源六郎教授，坂本捷房教授に感謝を捧げる．終りに本研究に対し終始支持と激励とをあたえられた那須所長に感謝する．

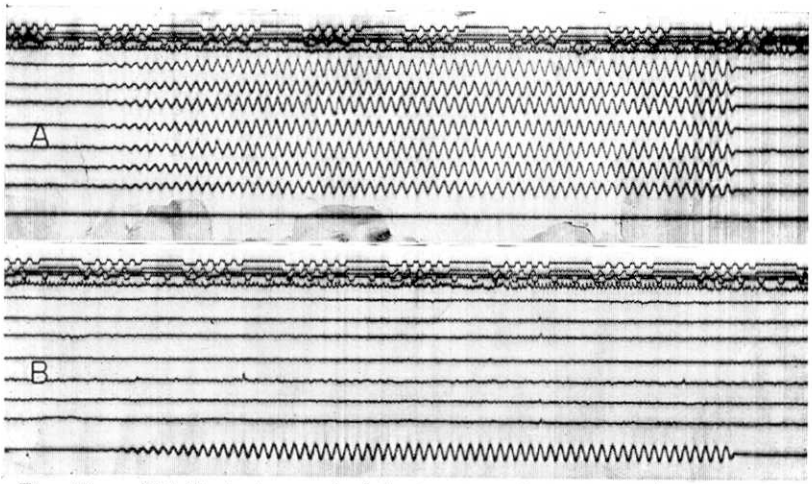

Fig. 10-a. Fidelity test record of the tape recorder system. An alternating voltage is applied in paralell to the seismometer terminal of respective seven channel. (1/4 the actual)

A; a record passing through the entire units, including the magnetic delay unit.

B; a direct record through the amplifier without passing through the magnetict tape. (B is recorded on a bromide paper 1.2 m ahead to A)

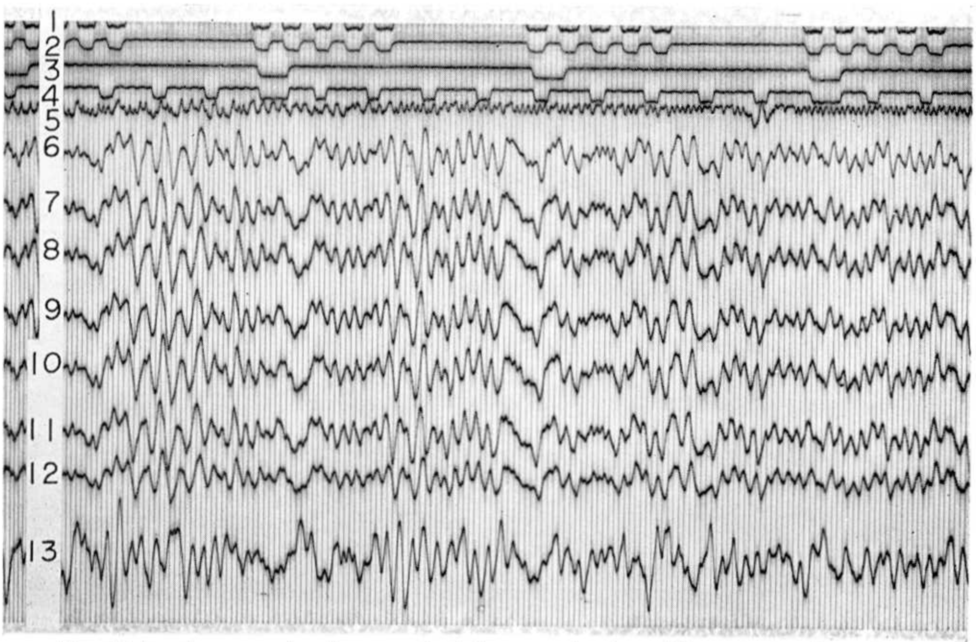

Fig. 10-b. An example of a record of the ground noise. The output voltage from a seismometer is fed in paralell to the seven channels of the magnetic tape recorder. (2/3 the actual)

Traces 1-4; time marks for second, minute and hour.
5; time mark from JJY time signal.
6-12; records of ground noise.
13; a direct record of ground noise, skipping the magnetic tape unit.

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