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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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31 January 1946

[redacted]

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Geophysical Research.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Target X-06 of Fascicle X-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lieut. S.W. Bailey, USNR, and Lieut. R.E. Anderson, USNR, assisted by Capt. M.S. Zaslow, AUS, and J.F. Plummer, T/4, AUS, as interpreters.

C. G. Grimes

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Captain, USN

30688

~~RESTRICTED~~ X-06

JAPANESE GEOPHYSICAL RESEARCH

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE X-1, TARGET X-06

JANUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

JAPANESE GEOPHYSICAL RESEARCH

Japan has long been outstanding in the field of geophysics, particularly seismology. During the war years, however, shortages of material, personnel, and money combined with bombings to greatly limit instrument development and research.

The following developments in seismograph design of recent years are described and illustrated:

1. Matsuzawa Duplex Pendulum Seismograph (a new design to measure displacement of strong earthquakes).
2. Sassa Strain Seismograph (after Benioff, to measure velocity).
3. Sassa Extension Meter (to measure horizontal displacement).
4. Hagiwara Displacement Seismograph (with new type calibrating device).
5. Hagiwara Vertical Motion Seismograph (with rectangular suspension).
6. Tsuboi Clock Drive for Seismometer Drum.
7. Sassa Type "B" Prospecting Seismograph.
8. Sassa Type "C" Prospecting Seismograph.

The following tilting instruments are described and illustrated:

1. Sassa Clinograph (after Schluter).
2. Ishimoto Tiltmeter.
3. Water Level Instrument.

The geophysical principles involved in the following land mine detectors are described:

1. Seismometer Type.
2. Non-metallic Type.

The following gravity instruments are described and illustrated:

1. Tsuboi Gravity Pendulum.
2. Hasegawa Gravity Variometer.

No new magnetic, radio-activity, electrical or thermal instruments were descovered.

Japanese geophysicists have long worked toward forecasting earth disturbances. The most significant results have been obtained from tilting and magnetic anomalies, which are discussed together with other lines of research which have been followed.

The concluding portion of the report deals with views held by Japanese scientists on such theories as the state of the earth's core, isostasy, earth tides, crustal deformation and the earth's ellipsoid.

TABLE OF CONTENTS

REFERENCES

Locations of Targets:

Earthquake Research Institute, Tokyo Imperial University, TOKYO.
Geophysical Institute, Tokyo Imperial University, TOKYO.
Geophysical Department of the Geological Survey, Department of Commerce, TOKYO.
Tohoku Imperial University, SENDAI.
Kyoto Imperial University, KYOTO.
Abuyama Seisological Laboratory of the Kyoto Imperial University, TAKATSUKI, Osaka Ken.
Nagoya Imperial University, NAGOYA.
Mitsui Geophysical Observatory, SHIMODA, Izu Peninsula.
Central Meteorological Observatory, TOKYO.

Japanese Personnel Interviewed:

Tokyo Imperial University:
- H. TSUYA, Director, Earthquake Research Institute.
- T. HAGIWARA, Seismologist, Earthquake Research Institute.
- H. KAWASUMI, Seismologist, Earthquake Research Institute.
- C. TSUBOI, Professor of Geodesy, Geophysical Institute; Member, Earthquake Research Institute.
- T. NAGATA, Professor of Electricity and Magnetism, Geophysical Institute.

Kyoto Imperial University:
- M. MATSUYAMA, Former Professor of Geophysics; President Geodetic Commission, Department of Education.
- M. HASEGAWA, Professor of Electricity and Magnetism; Director of Volcanic and Hot Spring Institute.
- K. SASSA, Professor of Seismology; Director, Abuyama Seismological Laboratory.
- E. NISHIMURA, Assistant Professor of Seismology.
- J. HATSUDA, Lecturer, Radioactivity of Rocks and Minerals.
- J. TAKUBO, Lecturer, Geology and Mineralogy.

Nagoya Imperial University:
- K. ARIYAMA, Professor of Physics.
- N. MIYABE, Professor of Geophysics; formerly at Earthquake Research Institute, Tokyo Imperial University.

Tohoku Imperial University:
- S. NAKAMURA, Professor of Geophysics.

Geological Survey:
- T. FUCHIDA, Directory, Geophysical Department.

Mitsui Geophysical Observatory:
- Y. KOSHIKAWA, Director; Research Geophysicist in Terrestrial Magnetism.

Central Meteorological Observatory:
- K. WADACHI, Seismologist and Chief Meteorological Forecaster.
- U. INOUE, Seismologist; formerly at Earthquake Research Institute, Tokyo Imperial University.

LIST OF ENCLOSURES

(A) List of Documents Forwarded to Washington Document Center via ATIS.

LIST OF ILLUSTRATIONS

INTRODUCTION

This report is concerned with recent Japanese development in geophysical instruments, data and theory, particularly in regard to earthquakes and volcanoes.

The problem was investigated by first securing from the Japanese a listing of all organizations and individuals working in geophysics. These were catalogued according to type of work and relative importance. It was found that nearly all geophysical work was sponsored by the government and carried out by professors at the various Imperial Universities and by trained personnel at government observatories.

All the major universities and observatories were visited and cognizant personnel interviewed. In interviewing, an effort was always made to secure a description of work carried on during the war and for a few years prior to the war. New designs in instruments and modifications of existing designs were stressed and developments in theory and data noted. Particular emphasis was placed upon seismology. All published material of interest was obtained. Laboratories and equipment were inspected in all cases and photographs obtained of the newer instruments.

THE REPORT

Part I - GENERAL

Japan has long been noted as the most active earthquake land area in the world, being the center of disturbances of both the volcanic and tectonic types. Prior to the war, the Japanese were outstanding in the field of geophysics, particularly in seismology. Conditions during the past few years, however, have greatly limited research, and full advantage has not been taken of the existing possibilities.

Material shortages accounted for much of the curtailment, particularly the scarcity of alloys for springs and the nearly complete lack of photographic supplies. Personnel problems also had their effect. Large numbers of research assistants had been taken into military service, while many of the remaining geophysicists were diverted to other fields of study. Insufficient financial support has always been a limiting factor in Japanese research, often necessitating the construction of inferior mechanisms. Lastly, the lack of information from the outside world during the war and actual interference due to bombings further restricted research.

Geophysical prospecting in Japan has never attained the prominence which it has enjoyed in the United States. The very limited occurrence of oil in the Japanese home islands and the complexity of ore structures are the chief reasons for the inactivity in this field. A few instruments have been designed in recent years, but they are inferior to foreign models. The only organization which is wholly concerned with prospecting is the Geophysical Department of the Geological Survey. Its activities are confined to survey work, however, for which American and German instruments are preferred.

Part II - INSTRUMENTS

The instruments discussed here are all new designs or new modifications of known types which have been developed by Japanese geophysicists during recent years. No new instruments in the fields of magnetic, radioactive, electrical, and thermal methods were encountered in the course of the investigation.

A. Seismographs

1. Matsuzawa Duplex Pendulum Seismograph.

This instrument, now under construction at the Geophysical Institute of Tokyo Imperial University, is a new design developed by T. MATSUZAWA. It is a long period seismograph for the measurement of displacement of strong earthquakes. As shown in Figures 1 and 2, the instrument consists of two coupled pendulums for each component.

The pendulums are connected by three flat springs as shown in Figure 3. The two outer springs (Nos. 1 and 3) are similar in size and attachment. The center spring (No. 2) is twice the width of either of the other springs and is attached to the opposite ends of the pendulums. Thus, the tension is equalized in both directions. The purpose of this arrangement is to eliminate the effects of vertical motion in measuring the horizontal compenent, and vice versa. For any vertical motion acting on one pendulum of the horizontal component system, an equal and opposite force is exerted on the other pendulum, thereby cancelling the effect. The same principle applies to the elimination of horizontal motion from the vertical component system.

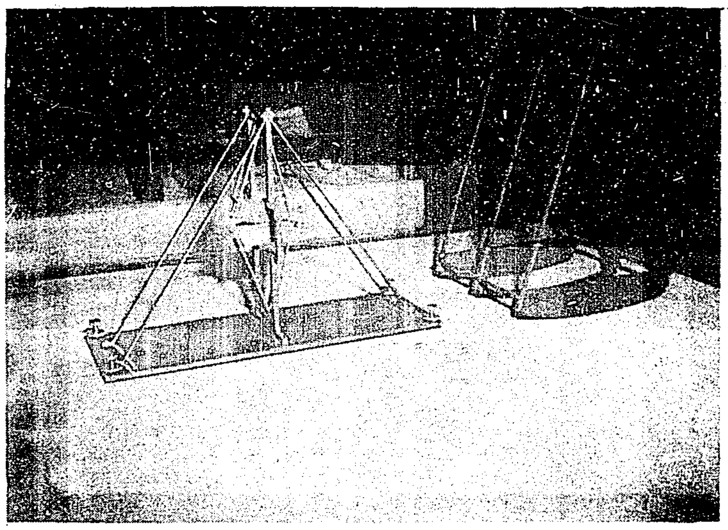


Figure 1

MATSUZAWA DUPLEX PENDULUM SEISMOGRAPH
Model of horizontal component and one pendulum for actual instrument.

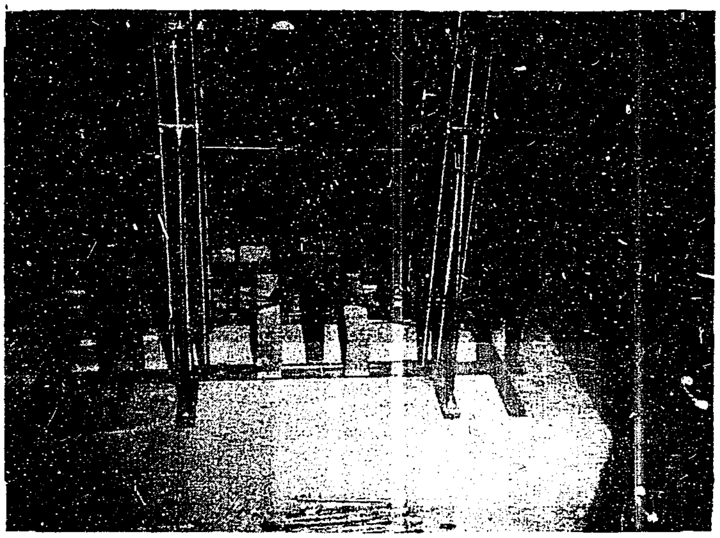
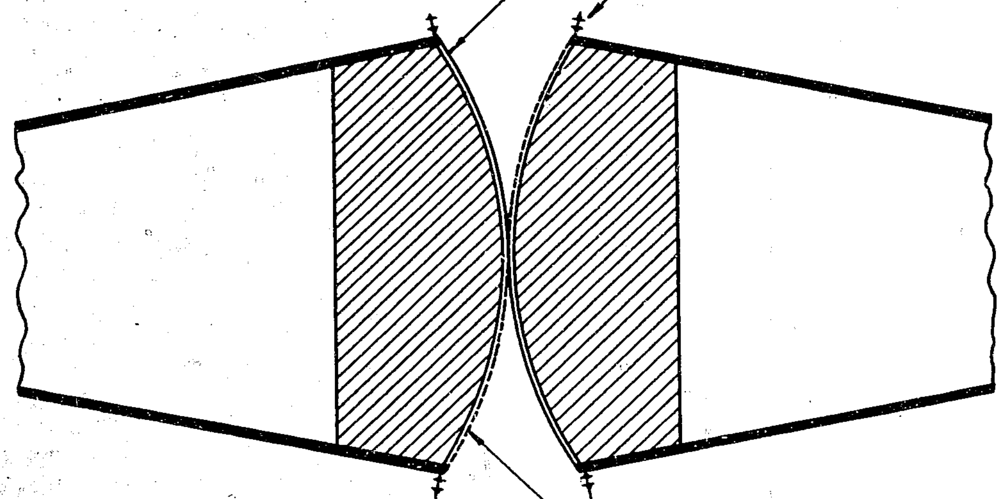


Figure 2

MATSUZAWA DUPLEX PENDULUM SEISMOGRAPH VERTICAL COMPONENT
(Pendulums are blocked-up during construction.)



MATSUZAWA DUPLEX PENDULUM SEISMOGRAPH
SPRING ARRANGEMENT

Figure 3

Note: Spring No. 3, not shown in Figure 3, occupies corresponding position to No. 1, but on the opposite side of the pendulums.

The Matsuzawa Duplex Pendulum Seismograph employs magnetic damping, optical recording and a support arrangement which compensates for temperature variations.

The period of the pendulums varies with the tension applied to the coupling spings and is estimated to have a maximum value of 60 seconds.

The theory of this instrument is discussed in NavTechJap Document No. ND 50-5356.

2. Sassa Strain Seismograph.

In 1938 Dr. K. SASSA of the Kyoto Imperial University developed the Sassa Strain Seismograph to measure the velocity of seismic waves. This instrument, now in use at the Abuyama Seismological Observatory, is patterned after an instrument developed by Benioff in 1935. It differs, however, in using a steel wire rather than a pipe.

In principle, the strain seismograph consists of a steel wire twenty-five meters in length stretched taut between two anchored concrete piers. At one end the wire is attached to a helical spring and to a flat coil resting in the field of a fixed magnet (see Figure 4). Seismic waves cause the concrete piers to oscillate, varying the strain or tension on the steel wire and helical spring. The flat coil moves with the wire and spring, thus breaking the field of the fixed magnet and providing a measure of the velocity of the seismic waves.

The theory of this instrument and results of experiments are discussed in NavTechJap Document No. ND 50-5357.

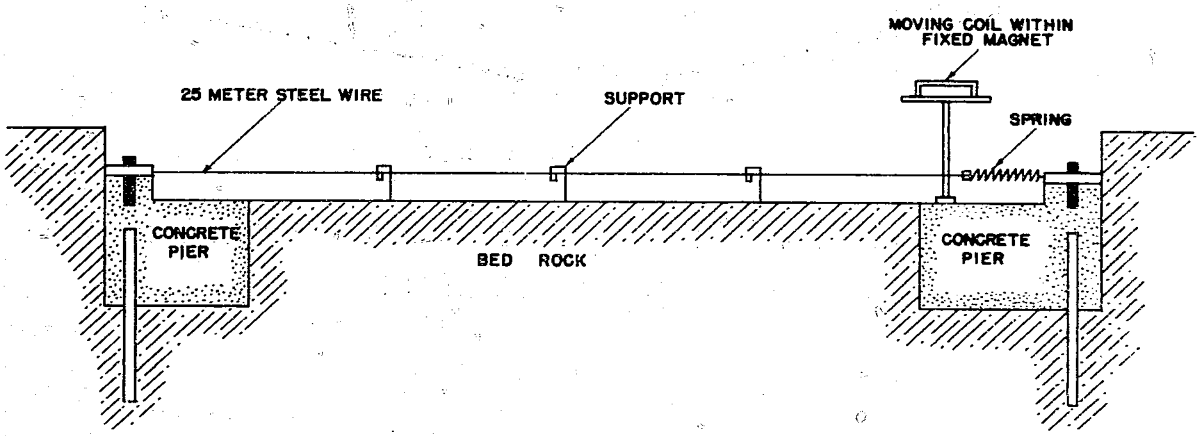


Figure 4

SASSA STRAIN SEISMOGRAPH

3. <u>Sassa Extension Meter</u>

Dr. K. SASSA of the Kyoto Imperial University developed the Sassa Extension Meter to measure horizontal displacements caused by seismic waves. The instrument is now in use at the Abuyama Seismological Observatory.

Two concrete piers are located twenty-five meters apart. A wire of super-invar is so stretched between the piers that its center sags about twenty-five centimeters below the level of the attached ends. At this center a small weight is suspended. The weight at the same time is connected to a metal stand by two thin crossed wires in a bifilar suspension (see Figure 5). Seismic waves cause the concrete piers to oscillate and the wire between to move up and down. The bifilar suspension translates the vertical motion of the small weight to a rotary motion. This rotary motion is recorded by reflecting a beam of light from a mirror attached near the weight onto photographic paper.

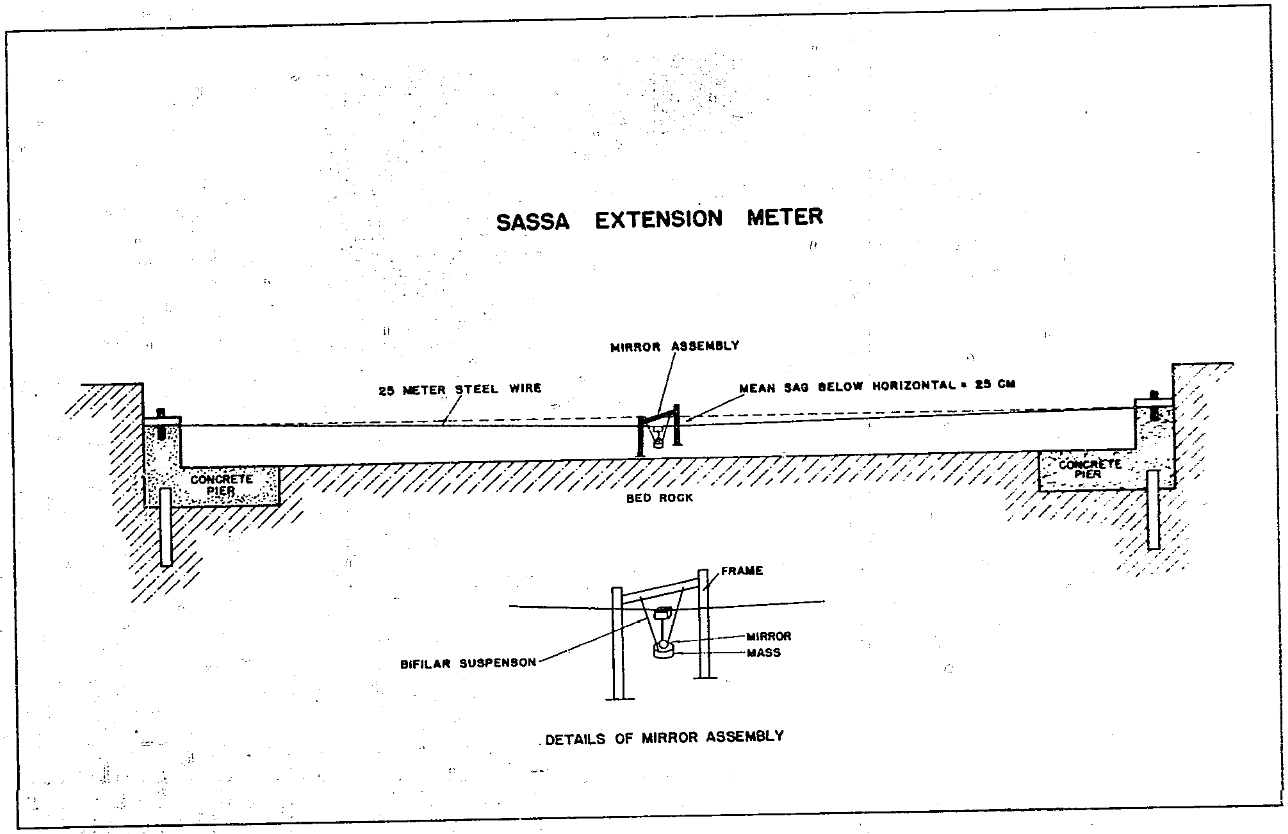


Figure 5

SASSA EXTENSION METER

4. Hagiwara Displacement Seismograph with Calibrating Device

This instrument, completed in 1945, is of the inverted pendulum type. Except for the damping arrangement, which consists of an air chamber built around one side of the pendulum mass as shown in Figure 6, the instrument itself has no new features.

Figure 6

HAGIWARA DISPLACEMENT SEISMOGRAPH

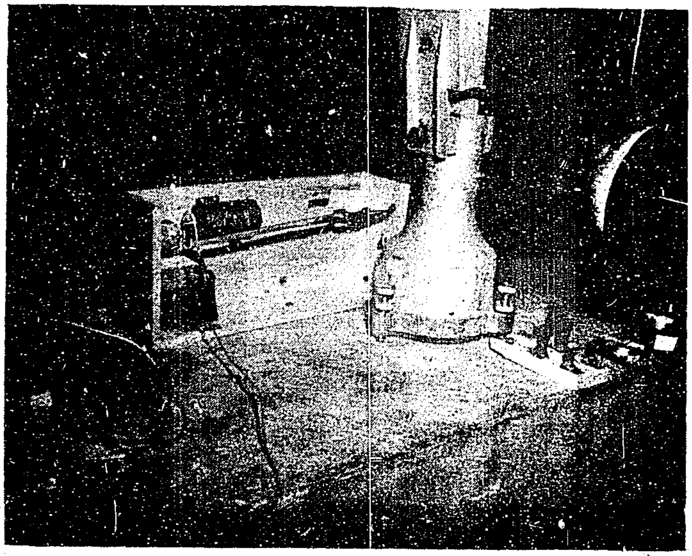


Figure 7

CALIBRATING DEVICE FOR THE HAGIWARA DISPLACEMENT SEISMOGRAPH

The calibrating device designed by HAGIWARA for this instrument is of considerable interest. As shown in Figure 7, a small mass suspended from the invested pendulum by a string, is oscillated by a bar connected to an eccentric cam geared to a small electric motor. The period of oscillation of the small mass can be varied from 1 second to 10 seconds and maximum amplitude is used. Thus, the force being applied to the inverted pendulum seismograph can be calculated and the resulting deflection on the smoked drum can be evaluated.

The Hagiwara Displacement Seismograph has 30 power magnification and a free period of 8 seconds. The weight of the pendulum is 8kg.

5. Hagiwara Vertical Motion Seismograph

Dr. T. HAGIWARA of the Earthquake Research Institute of Tokyo Imperial University has designed a seismograph to record the vertical displacement of seismic waves. This instrument is in the process of construction.

The Hagiwara Vertical Motion Seismograph utilizes a conventional horizontal pendulum attached by flat springs at one end and suspended by a helical spring near the other end. The helical spring (BA) is attached at an angle to the pendulum and perpendicular to a line (OB) drawn from the pivot point of the pendulum through the suspension point of the spring (see Figure 8).

HAGIWARA VERTICAL MOTION SEISMOGRAPH

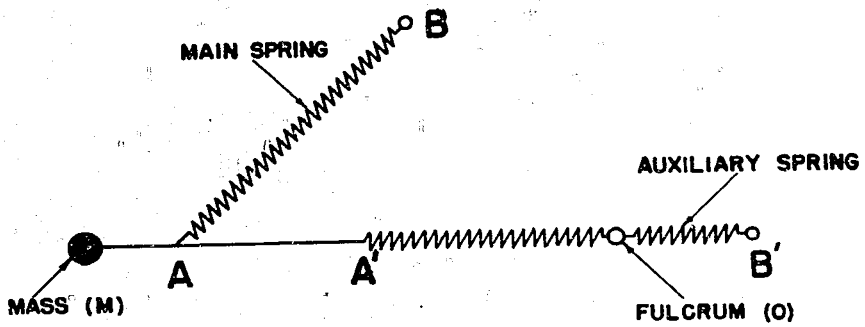


Figure 8

This "rectangle suspension" gives a longer free period for the pendulum than was gained by previous types of suspension. An auxiliary horizontal spring (A' B') is attached to the pendulum to increase the period further to a maximum of ten seconds.

The theory of this seismograph is discussed in NavTechJap Document No. ND 50-5358.

6. <u>Tsuboi Clock Drive For Seismometer Drum</u>

Due to material shortages and the necessity for construction of less expensive instruments, precise clock work mechanisms for seismograph drums becomes a major problem confronting Japanese geophysicists. The Tsuboi Clock Drive is one solution to this problem and a good example of improvising in the laboratory.

Figure 9 shows the actual instrument, with the bell jar removed. Note the rubber hose leading from the base which is attached to a vacuum pump.

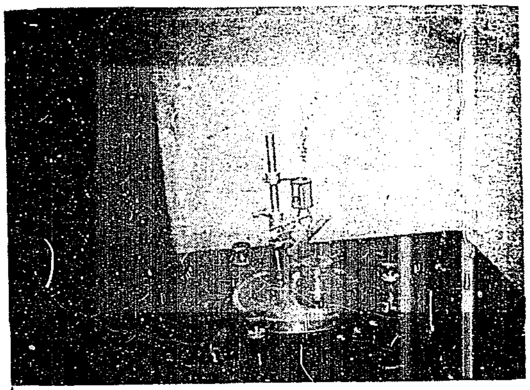


Figure 9

TSUBOI CLOCK DRIVE FOR SEISMOMETER DRUM (Bell jar removed).

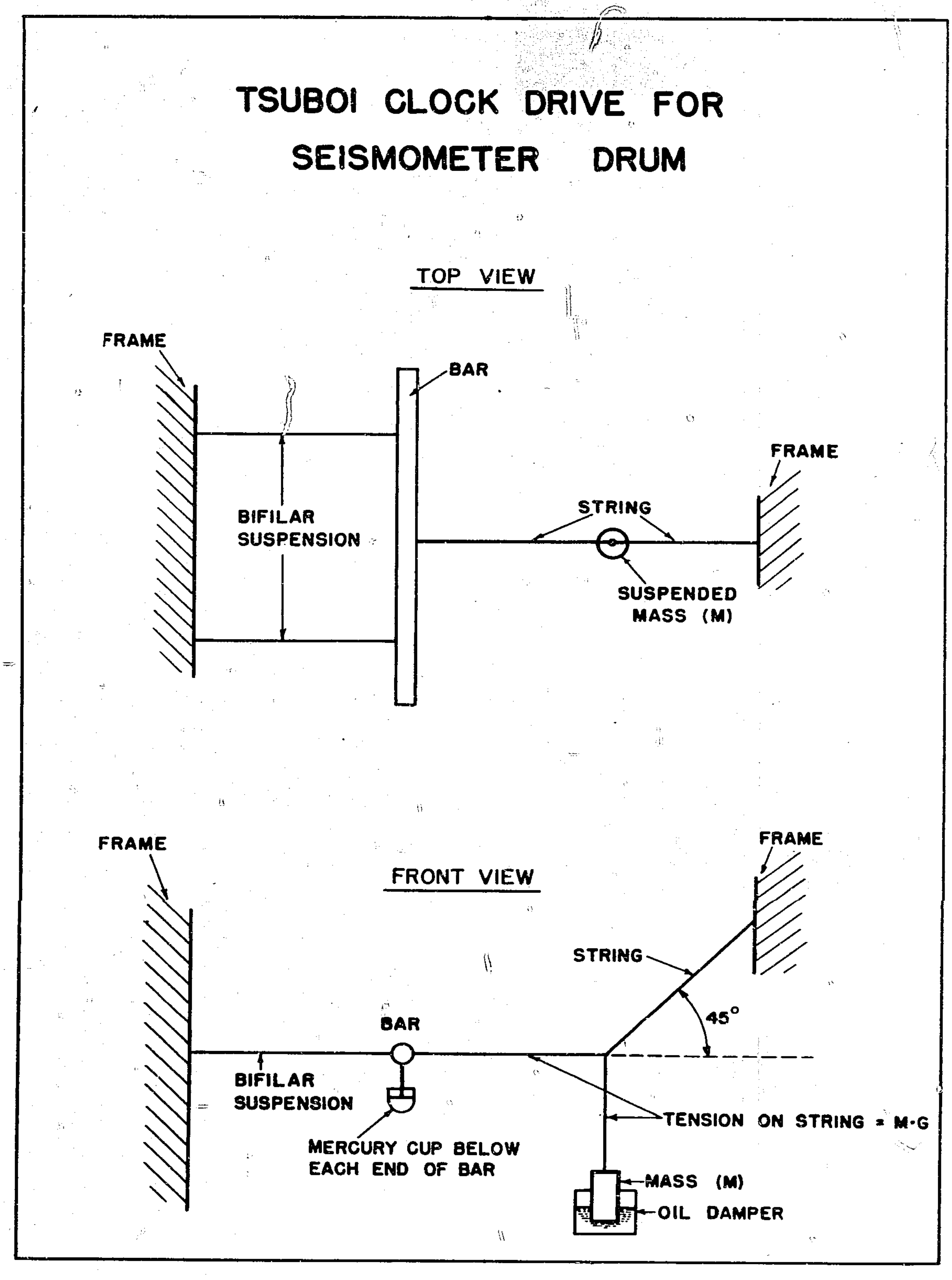

TSUBOI CLOCK DRIVE FOR SEISMOMETER DRUM
TOP VIEW
FRAME
BAR
FRAME
BIFILAR SUSPENSION
STRING
SUSPENDED MASS (M)
FRAME
FRAME
FRONT VIEW
STRING
45°
BAR
BIFILAR SUSPENSION
TENSION ON STRING = M·G
MERCURY CUP BELOW EACH END OF BAR
MASS (M)
OIL DAMPER

Figure 10

Figure 10 is a schematic diagram of the clock drive instrument. The small bar is a pendulum oscillating about a horizontal axis and supported by horizontal bifilar suspension on one side and by a string connected to a mass (M) on the other side. The string in turn is supported by a second string to the frame. Since the second string is at an angle of 45° the tension in both the horizontal and vertical segments of the main string is equal to M·g where g is the force of gravity. Thus, the period of the bar pendulum depends on the force of gravity.

Below each end of the bar, small attached wires dip alternately into mercury cups as the pendulum oscillates. Direct current is introduced into the system through the bar and, as contact with the mercury cups is made and broken, alternating current is produced, while at the same time the oscillation of the bar is accomplished. Thus, controlled current drives the motor for the seismometer drum and produces a steady rotation.

This instrument and other precision recording apparatus are further discussed in NavTechJap Document Nos. ND 50-5359 and ND 50-5360.

7. Sassa Type "B" Prospecting Seismograph

In 1938 Dr. K. SASSA of the Kyoto Imperial University developed a portable, three-component seismograph for use in geophysical prospecting and in studying seismic wave properties. This instrument succeeded an earlier single-component model and is known as Type "B".

The Sassa Type "B" Seismograph is shown in Figure 11. It consists of two inverted pendulums to measure the horizontal components of velocity and a horizontal pendulum supported by a vertical spring to measure the vertical component.

Magnetic damping is used in all three components and a flat coil breaking the field of the magnet provides a measure of the velocity. The period of the pendulum is 0.3 second, the period of the galvanometer 1.15 second. The magnification is 70,000 times for waves of 1/20 second.

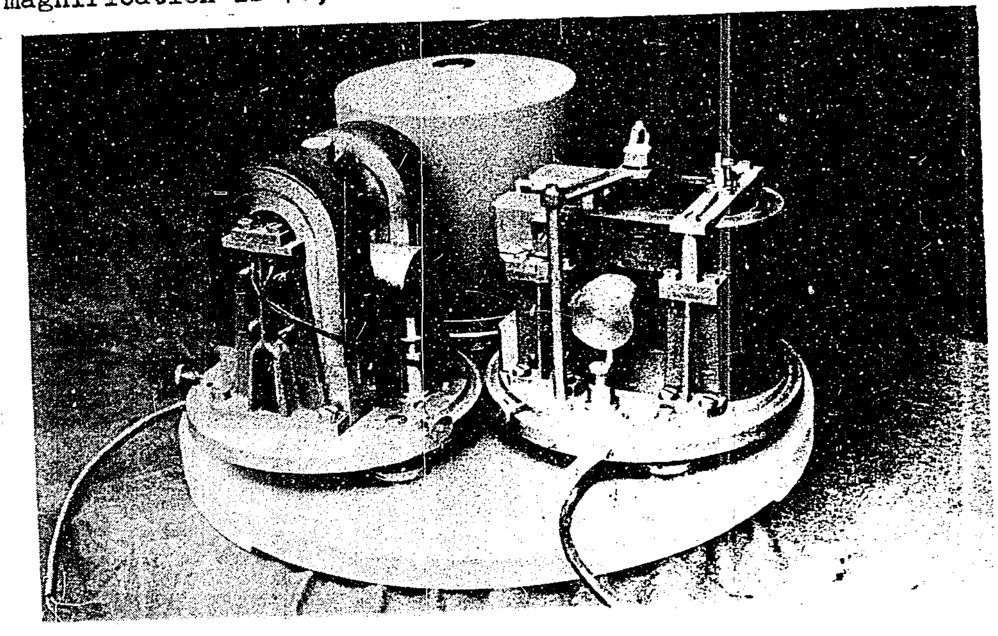


Figure 11

SASSA TYPE B PROSPECTING SEISMOGRAPH

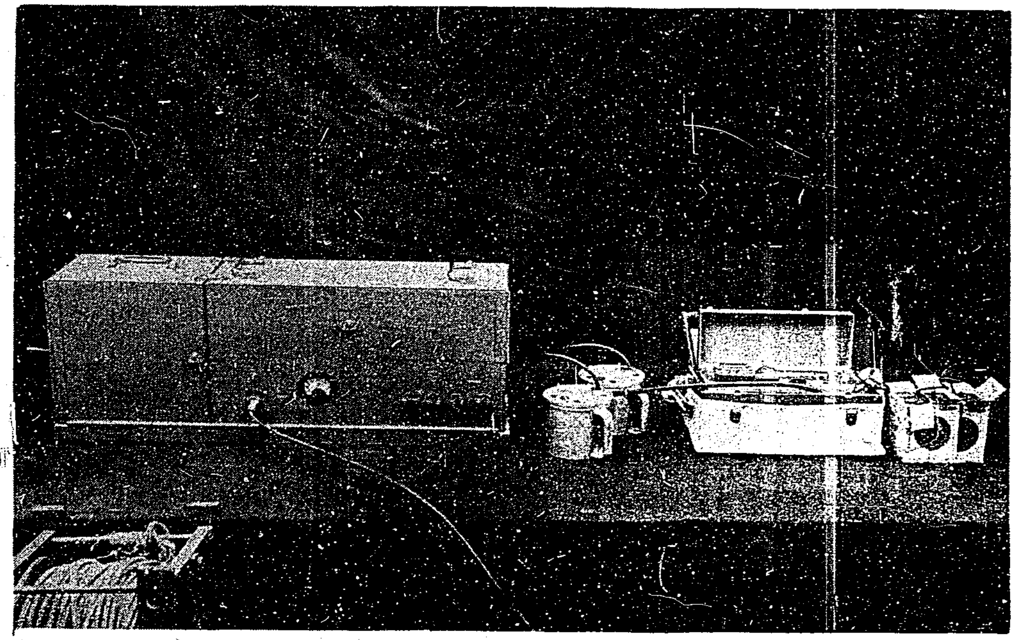


Figure 12

SASSA TYPE C PROSPECTING INSTRUMENT

8. Sassa Type "C" Prospecting Seismograph

This instrument does not represent an advancement in design, but it is included here because it is a type considered to be one of the best of the Japanese prospecting instruments. It consists of a moving coil in a fixed magnetic field and has 30,000 power magnification. The free period is 1/15 second and the tuning fork shown with the rest of the apparatus in Figure 12 is the timing device.

B. Tilting Instruments

Progress in development of tilting instruments in Japan during the past 15 years has been practically at a standstill. The improvements observed in the course of this investigation consisted wholly of slight modifications of known types of instruments.

For the very slow annual tilting of the earth's surface, precise relevelling remains as the method used.

For very short period tilting, such as that which accompanies earthquakes or volcanic eruptions, Dr. K. SASSA has constructed several clinographs of the Schluter Type. These instruments vary only slightly from the original model and the Galitzin adaptation in such details as the period of the clinograph and the period and resistance of the galvanometer. SASSA's instrument is shown in Figure 13 and discussion of experiments conducted is given in NavTechJap Document No. ND 50-5357.

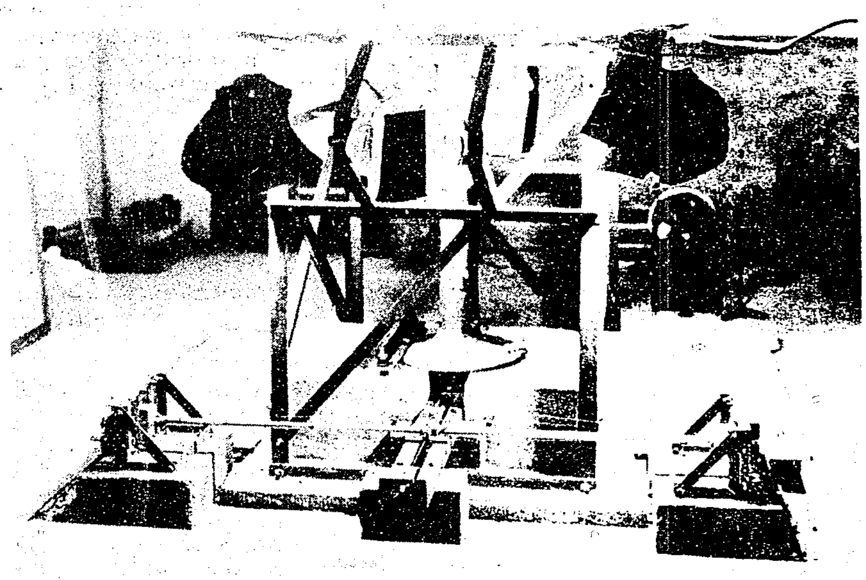


Figure 13

SASSA CLINOGRAPH, AFTER SCHLUTER AND GALITZIN

For longer period tilting, such as that caused by tides, the Ishimoto Tiltmeter, devised over 15 years ago, is the most recent instrument. Very slight modifications, such as the nature of the materials used and the levelling adjustments, have been incorporated. An example of one of the more recent models which was built by Dr. E. NISHIMURA of Kyoto Imperial University is shown in Figure 14.

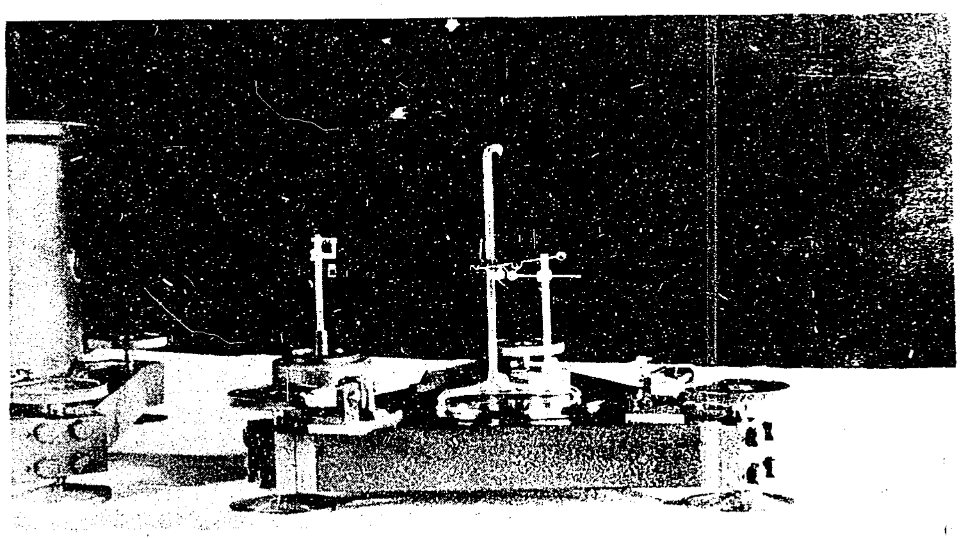


Figure 14

ISHIMOTO TILTMETER

The only other means of measuring the earth's tilt which were encountered were water level experiments. The Tokyo Imperial University maintains an observatory at Mt. TSUKUBA, north of TOKYO, which contains a water level instrument 20 meters in length. Experiments have also been conducted using the large water body of Lake BIWA for tilt measurements.

C. <u>Land Mine Detectors</u>

Dr. S. NAKAMURA of Tohoku Imperial University expended the major portion of his time and effort during the war years in an attempt to perfect a seismic-wave land mine detector. His experiments were directed toward the construction of two types of instruments. Neither of these instruments was successful, but the principles involved and the reasons for failure are of considerable interest.

The first line of investigation was based on the principle of generating seismic waves by means of a small motor and measuring the waves reflected from the land mines on a seismometer. In the course of the experiments, it was discovered that a wave length of about 10 yards was needed. This could not be produced and the research had to be abandoned.

The second instrument which was devised is shown in Figure 15. Alternating current was introduced into the electromagnets and the resulting attraction and repulsion of the pole pieces for the iron base caused the magnets to oscillate on the steel spring plate. The vibrations set up would thus enter the ground as seismic waves. As a mine was approached, reflected waves would be received by the iron base and these would further aid the vibration of the instrument. As the reflected waves returning increased, the output of the oscillator supplying AC to the system would decrease. This value was then used to indicate the buried mines and no additional recording apparatus was needed.

This instrument proved to be impractical before its completion due to the size of the oscillator needed, and was, therefore, never finished. The war ended before the designer could begin a new instrument of portable size.

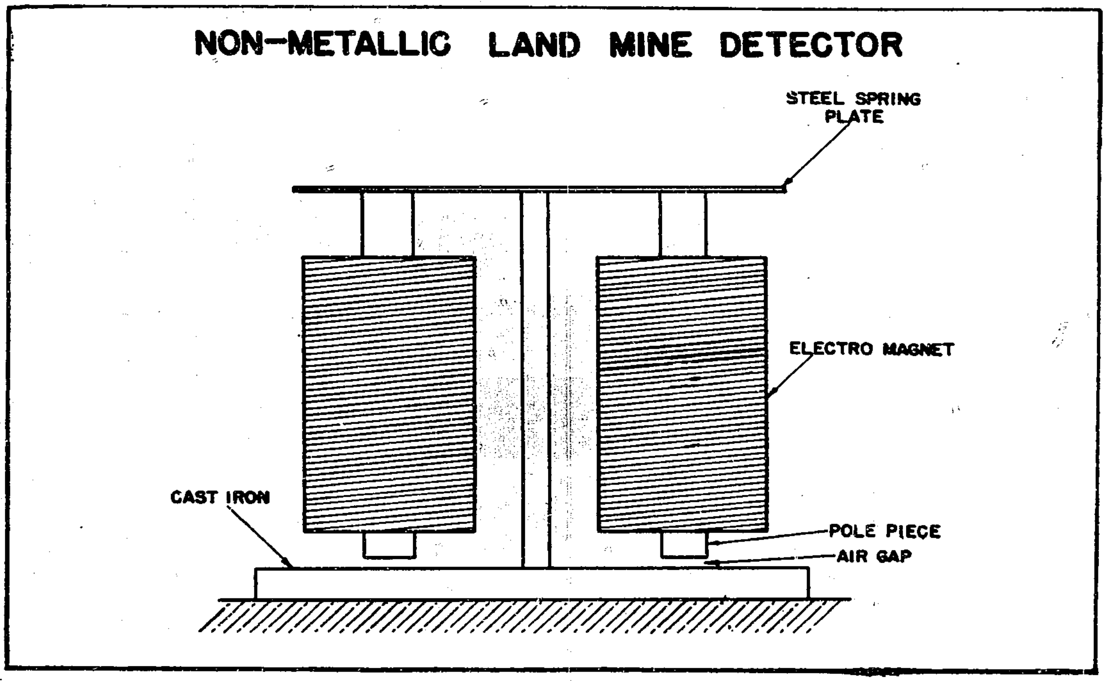


Figure 15

D. Gravity Instruments

1. Tsuboi Gravity Pendulum

This instrument was built by Dr. C. TSUBOI of Tokyo Imperial University, and was completed in 1942.

The gravity pendulum does not represent any radical changes in principle or design from known types. It is, however, a very well constructed instrument and should be capable of a high degree of accuracy. Figure 16 shows an exterior view of the instrument and the vacuum pump. Figure 17 shows the inside portion of the instument after removal from the casing and without the two silica pendulums. Both pendulums are inserted prior to making recordings and either one may be lowered onto its knife edge by an exterior adjustment. The knife edge pivots on an agate block and photographic recording is used.

When making gravity measurements two instruments are used, one in the laboratory. The period of the field instrument is transmitted to the laboratory via radio and the records of both instruments are recorded on a single film.

The radio transmitter method of gravity measurements and results of observations are discussed in NavTechJap Documents Nos. ND 50-5361 and ND 50-5362.

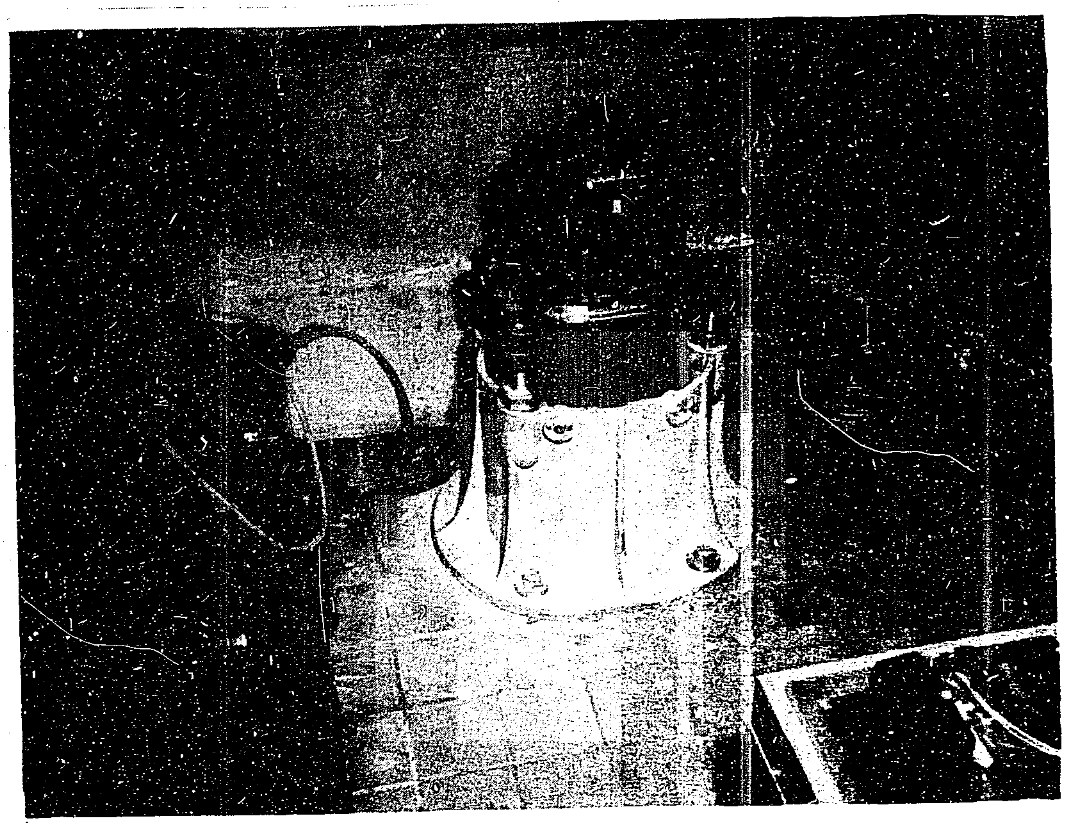


Figure 16

TSUBOI GRAVITY PENDULUM

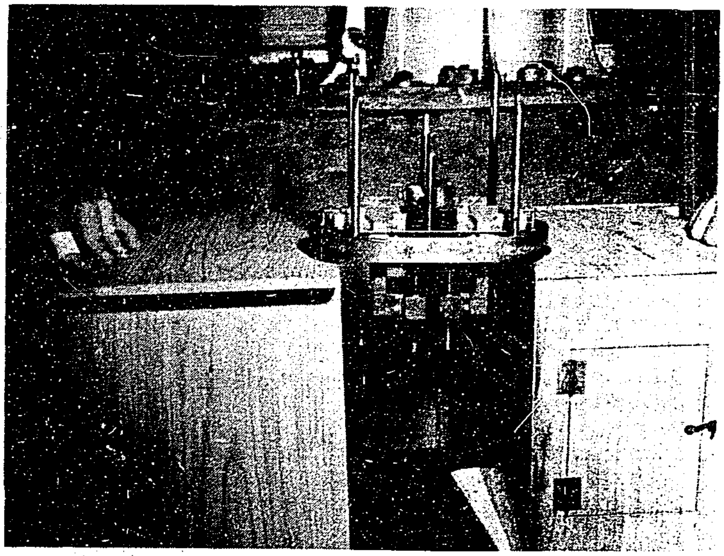


Figure 17

INTERIOR MECHANISM OF TSUBOI GRAVITY PENDULUM

2. Hasegawa Gravity Variometer

Dr. M. HASEGAWA of Kyoto Imperial University has designed a gravity variometer for use in geophysical prospecting. This instrument is patterned after the Humble Oil Co. Toolman Type and is now under construction.

Instead of using one vertical and one horizontal pendulum as in the Humble Oil Co. Type, HASEGAWA has incorporated a second horizontal pendulum in addition. This is for the purpose of correcting small errors in adjustment of the instrument. Each pendulum is supported by four springs. These springs are made of elimvar and so pieced together that each contains compensating elements to eliminate large changes due to temperature variations. The instrument is further kept at a constant temperature as far as possible. Optical recording is used.

Part III - FORECASTING EARTH DISTURBANCES

The frequency and severity of earthquakes and volcanic eruptions in Japan have led Japanese geophysicists quite naturally to devote considerable time to the problem of forecasting such phenomena. This investigation found such workers quite divided in opinion as to the future success of their efforts.

Dr. Y. KOSHIKAWA, Director of the Mitsui Geophysical Observatory, is most confident of success. He has worked on this problem since 1938 and believes that in ten years disturbances can be fairly accurately predicted. He believes terrestrial magnetism observations to be the most important means for predicting both volcanic eruptions and small and large scale earthquakes. Accordingly he has worked at determining magma movements by taking magnetic surveys over active areas.

As an example of his work, KOSHIKAWA cites the earthquake of 13 January 1945 centering in the ATSUMI Peninsula. He was making magnetic observations at KAWASAKI, Shizuoka Prefecture from 9-12 January. By 11 January he was convinced a disturbance would occur in that general area, but could not give the time, exact location, intensity or type of disturbance. From his observations he stated that if it were to be a volcanic eruption, it would occur within a radius of 30 kilometers from KAWASAKI, and if it were to be a large earthquake, it would be within a radius of 200 kilometers. Actually, an earthquake occurred two days later 70 kilometers east of KAWASAKI.

KOSHIKAWA pointed out that his readings were taken at only one station and that if several stations were utilized the epicenter could be determined more exactly. He considers the location factor easiest to determine, intensity next and time the hardest. At the present time his survey methods merely indicate whether a disturbance is impending in that general area within a maximum period of seven days.

Dr. N. MIYABE of Nagoya Imperial University, on the other hand, apparently has little faith in the future of KOSHIKAWA's experiments. MIYABE has worked on crustal deformation by means of precise relevelling and does not believe that earth disturbances can be predicted.

The entire geophysical staff of the Kyoto Imperial University has been engaged in observing phenomena which precede and accompany earthquakes. Their general opinion is that KOSHIKAWA's method alone will not solve the problem. Dr. M. HASEGAWA, head of the Department of Geophysics, stated that some, but not all, volcanic quakes are preceded by magnetic variations. He has tried forecasting by mapping magma movements as indicated by magnetic variations, but has been unsuccessful.

Dr. K. SASSA and Dr. E. NISHIMURA, of the same staff, have been interested in all sudden changes which accompany earthquakes. Using the Ishimoto Tiltmeter, as modified by NISHIMURA, they have been successful in observing marked changes in level prior to and after earthquakes. (See NavTechJap Document No. ND 50-5363). As a result of their observations they feel that the occurrence of large earthquakes can be predicted by use of the tiltmeter alone. The prediction of exact location, intensity and time, however, is a matter of the very distant future, as is the prediction of smaller disturbances.

Dr. J. HATSUDA of the Geology Department of Kyoto Imperial University has made the interesting observation that the radioactivity of soil gases at KYOTO increased sharply about 24 hours prior to the severe earthquake of 7 December 1944 centering in KUMANO NADA, south-east of KISHU Peninsula. Unfortunately he has had no opportunity for further observations.

Dr. S. NAKAMURA of Tohoku Imperial University has studied the magnetic anomalies occurring in the earth as a means of predicting earthquakes. In four instances he has recorded sharp increases in dip about six months prior to an earthquake. The sharp increase is followed by a quiet period leading up to the quake. (See Figure 18.) The effective radius of these observations varies greatly with the intensity of the earthquake but may be as great as 200 kilometers.

Dr. NAKAMURA believes that the general region of a quake can be determined by statistical methods and that magnetic anomalies can be used to determine intensity. He is aware of fluctuations in the natural earth currents 24 hours prior to a quake but believes this too short notice to be practical. In general, he feels there are not enough recorded pre-earthquake phenomena to draw any conclusions.

Members of the Geophysical Institute of Tokyo Imperial University have done considerable work on earthquake and volcanic phenomena. Dr. T. NAGATA has found that after-shocks are preceded about two hours by strong increases in natural earth currents. He attributes this to an increase in conductivity due to stress.

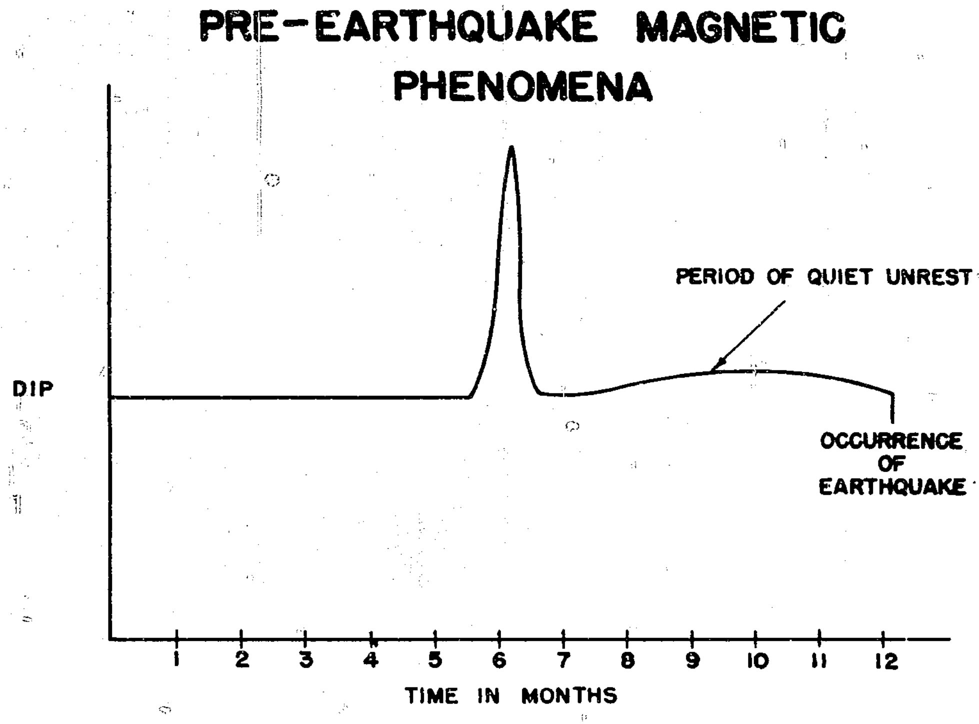


Figure 18

The Geophysical Institute has an observatory at Mt. ASAMA where all types of geophysical measurements are made. Dr. NAGATA stated that the Ishimoto Tiltmeter has recorded tilting there two to four weeks prior to an eruption and that this is the only means of predicting eruptions. Dr. T. MINAKAMI of the Earthquake Research Institute has had considerable success in predicting eruptions by this method. Tilting measurements at Mt. ASAMA are discussed in NavTechJap Documents Nos. ND 50-5364 and ND 50-5365. A relation seems to exist also between eruptions and magnetic anomalies but there has not been sufficient work to define the relation exactly.

Dr. C. TSUBOI of the Geophysics Institute described an interesting experiment at the Mitaka Astronomical Observatory. In 1916 five geodetic base lines, each 100 meters in length, were laid out in the form of a rhombus oriented to the compass points. The base lines were remeasured at least once a year and were found to vary in length in a definite relation to the occurrence of earthquakes in that area. Expansion in the N-S direction was found to precede earthquakes centering to the SE. Contraction in the N-S direction was found to precede earthquakes centering to the NE. This work is described in NavTechJap Documents Nos. ND 50-5366 and ND 50-5367.

The foregoing describes the efforts of leading Japanese geophysicists to forecast earth disturbances in recent years. Opinions differ as to methods to be used and the likelihood of success. Considerable progress has been made, however, and the work continues in all fields.

Part IV - THEORY

During the course of this investigation, the geophysicists were often questioned as to their opinions on earth theories in an attempt to obtain a cross-section of those theories which are popular among contemporary Japanese scientists.

The nature of the core of the earth has always been a highly controversial problem. Although geologists and geophysicists throughout the world have been in general agreement that chemically it consists of heavy nickel-iron compounds, its physical state is a much argued question. Nearly all Japanese geophysicists subscribe to the liquid-center theory, although a few of the older generation do not. The supporters of this theory cite, as the primary reason, the inability of shear waves to penetrate the core.

Isostasy is another theory which receives considerable time and thought, since Japan is an area of unstable isostatic condition. Dr. C. TSUBOI is one of the leading investigators in this field and NavTechJap Documents Nos. ND 50-5362 and ND 50-5373 discuss his observations of the effect of underground mass distribution and plane surfaces on gravity anomalies. Briefly, TSUBOI concludes that topography is determined by mass distribution rather than the reverse and that mountains represent a local thickening of the crust. He further states that it is questionable that isostatic equilibrium always occurs as a compensation for topographic masses, as is the case with deltas and glacial formations.

Earth tides have been studied by the Japanese, particularly by NISHIMURA of Kyoto Imperial University. The results of tilting measurements have revealed that the earth tides pulsate twice daily as do the ocean tides, but are in opposite phase. This is attributed to the interpretation that earth tides are caused by variations in the weight of water on the continental shelf. Thus, lunar variation is believed to be the greatest factor in earth tides.

During recent years, MATSUYAMA of Kyoto Imperial University and MIYABE of Nagoya Imperial University made gravity measurements in Manchuria. They eventually hope that similar measurements will be made thoughout Asia, for the purpose of calculating the earth's ellipsoid. In the past, such calculations have only been made from American and European data and they desire to check the results with similar work from Asiatic observations.

In his studies on crustal deformation by means of precise releveling. MIYABE has shown the fallacy of the popular conception that Japan as a whole is tilting. Instead, he has observed that various parts of the Pacific coast are rising, while others are subsiding. In addition, soil compaction in alluvial areas is taking place at a remarkable rate. This reached a maximum of about 10cm per year in the TOKYO area during 1938-1940 (see NavTechJap Document No. ND 50-5374).

Separation of the tilting and compaction effects has not been successfully accomplished as yet, but further relevelling and laboratory experiments on the properties of land masses are under way.

ENCLOSURE (A)

NavTechJap Document No.	Title	ATIS Doc. No.
ND 50-5356	A long-Period Seismograph for strong quakes.	4480
ND 50-5357	Microfilms of two papers on earthquakes.	4479
ND 50-5358	A note on the theory of the vertical motion seismograph.	4481
ND 50-5359	Construction of precise recording apparatus for seismograph.	4482
ND 50-5360	New drive for seismograph drum.	4483
ND 50-5361	Relative gravity measurements using long-range short-wave radio transmitter methods.	4484
ND 50-5362	Dependence on amplitude of the oscillation period of gravity pendulum.	4485
ND 50-5363	Changes in tilt at the time of the great TOTTORI Earthquakes.	4486
ND 50-5364	Explosive activities of the volcano ASAMA and tilting of the earth's surface.	4488
ND 50-5365	On volcanic activities and earth's surface tilting.	4487
ND 50-5366	Recent changes in area of base line rhombus at MITAKA.	4489
ND 50-5367	Secular deformations of base line rhombus at MITAKA in relation to seismic activities in vicinity.	4490
ND 50-5368	Geophysics, Vol. 5, No. 1.	4491
ND 50-5369	Vertical displacements in regions markedly deformed.	4492
ND 50-5370	On prior indications of major earthquakes.	4494
ND 50-5371	(Notes only) Theory of seismic waves and properties of elastic solid bodies.	4493
ND 50-5372	Gravity anomalies and underground mass distribution.	4495
ND 50-5373	Calculation of gravity as affected by undefined plane.	
ND 50-5374	Results of releveling in TOKYO, 1940.	4497