17. *Seismic Exploration of River Deposits.*

By Nobuji NASU,

Earthquake Research Institute.

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That seismic prospecting of the earth's superficial structure often provides considerable information valuable to the civil engineer in connexion with such work as bridge, tunnel, dam construction, etc., needs no stressing. In Japan, this method has in recent years been frequently used, particularly, by the Government Railways.

In order to help in designing the foundations of a number of the main bridges on the trunk main line, for which plans are now being drawn, the geological formations of the river beds crossed by these bridges were explored by the seismic method. This paper describes the results obtained along the Tokaido Line, over the Rivers Huzi, Tenryu, and Ooi.

Since precise descriptions of the methods and the instruments used in this exploration have already been published elsewhere, only brief explanations of them will be given here.

In all these works, the refraction method was used, that is, the time that elapses between the indication of the instant of explosion and the first disturbance as indicated by a seismograph at a measured distance from the shot point, is observed, the first disturbances alone being usually considered. Generally speaking, to interpret the seismograph results is not so simple as in the usual case in which the irregularity of the wave velocity distribution in each horizontal soil layer could be neglected. In the case of a river bed, there is considerable anisotropy in the velocity of the wave, especially in that propagated through the uppermost layer. In other words, the velocity parallel to the bedding is not the same throughout the layer.

The greatest drawback, and frequently a source of error, in the calculation of the refracting horizons, is the uncertainty regarding the determination of the velocity in the superficial layer. A desirable practice, therefore, in beginning the exploration is to carry out preliminary tests in order to determine the wave velocity in the surface zone. For these reasons, rigid determinations of the surface velocity were made at as many places as possible.

It should be added here that there were also considerable irregularities in the thickness of the layers of the river deposits, a lensing, or thinning out, of the beds being the general rule, in which case it is often difficult to plot the time-distance curve continuously, or to follow the same phase on the seismograms continuously, unless shot points at close intervals have been selected.

Usually, but, particularly, in the case of a complicated geological formation such as that just mentioned, since unique distribution of subsurface layers cannot be obtained from the observed time distance relations alone, the time-distance curves for a number of simple configuration of ideal elastic layers must first be calculated, and the results so adjusted as to fit them accurately.

The instruments used in the work just mentioned were mechano-optical detectors with a magnification of 40,000—a type of detector now obsolete, but having the merit of easy handling.

Results.

(a) The River Huzi.

Measurements were made along the lines AB, BA, BC, etc, (Fig. 1) coinciding with the center-line of the railway and lines HI and JK (Figs. 2 and 3) which intersected these lines at certain angles.

From the time-distance curves (Figs. 1, 2, 3), it was found that the velocity in the first layer was 600 m/sec, and those in the second and the third layers 1600 m/sec and 2300 m/sec respectively. The first and second layers were both gravel, but the second layer lay underneath the level of the underground water, with the result that the velocity in this layer showed a value exceeding that in the first layer. From the fact that the wave velocity that had been determined for the lava layer developed in places lying in an up-stream direction from the observed point agreed well with that calculated from the time-distanc curve, it was expected that the third layer would be a porous lava bed.

From the foregoing results, it may be said that there underlay, at the point where the exploration was made, a high speed medium, probably a porous lava stratum at a depth of from 10 to 20 m from the surface of the river bed.

(b) The River Ooi.

As will be seen from Figs. 4, 5, the observations were made along the main lines AB, BA, CD, etc, and the supplementary line XY.

The time-distance curve obtained from the seismograph results consisted of five segments, giving five different values of the wave velocity;

320 m/sec in the dry loose sand layer, 700 m/sec in wet gravel. 1600 m/sec in compact, but water-filled, gravel layer; 2100 m/sec in the diluvium layer, and 3100 m/sec in the tertiary rock bed.

The thicknesses of these layers are also shown in these Figs.

(c) The River Tenryu.

This exploration was made along the center-line of the railway designated AB, BA, CD, etc; A, B, C, D being the points of observation where the instruments were installed (Figs. 6, 7).

The time-distance curves showed that the wave velocity in the uppermost dry sand or gravel layer was 300 m/sec, while in the second, water-filled alternating layers of sand and gravel, it was 1500 m/sec. In places, this second layer consisted of the water-filled loose sand alone, in which the wave velocity was 1400 m/sec, or of waterfilled compact gravel in which the velocity was 1220 m/sec.

The third layer consisted of alternations of sand, clay, and gravel, the wave velocity through which was 2210 m/sec.

The thicknesses of the layers are shown in Figs. 6, 7.

From the results thus far mentioned, it may be said that, generally speaking, in the uppermost layer, the loose sand or gravel layer in which the wave velocity takes a value between 600 m/sec and 300 m/sec, has not sufficient bearing power for the foundations of such heavy structure as a railway bridge pier, with the result that the base for this structure must be set, at least, in the layers that underly it.

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17. 河川堆積物の彈性波式探査法

地震研究所 那須信治

土木工學の方面に於ても彈性波式地下探査法は有效であり，近年我國に於ては此方法が屢々實施されつゝある．殊に鐵道の諸工事の計畫に資せんがために此方法を實施した例は數多ある．

最近幹線の計畫のため橋梁に關し，此の方法を以て沿線の主要なる河川の地質調査が行はれた．本論文中には東海道線中の主要なる河川，富士川，天龍川，大井川に架設さるべき橋梁基礎の地質調査の結果を擧げておいた．

彈性波式探査法の屈折法を用ひ屈折波の走時曲線の解析により，彈性波の速度及び層の厚さを求めた．一般に河川の堆積層に於ては層の厚さ，及び彈性波の傳播速度が不規則であり．殊に最上部の層（多くの場合砂層）内に於ける傳播速度は場所によつて多いに異るため，走時曲線の解析に當つて誤差を生じるから，上層部の速度は綿密に調査し，且つ同一速度を有する砂層の區域をも注意して決定した．

使用した器械は器械的光學的に地動を四萬倍に擴大する微動計である.

富士川に於ては最上層內の速度 600 m/sec, 第二層 1600 m/sec, 第三層 2300 m/sec であることを知る. 第一, 第二層は共に砂利層なるも後者は地下水面下にあるため其の彈性波の傳播速度が前者に比し大なる値を示した. 第三層は上流に露出せる多孔質熔岩層に於て測定せる結果と其の傳播速度 (2300 m/sec) は完全に一致せる故, 測定箇所の第三層も同一岩盤より成るものと推定す.

天龍川に於ては走時曲線から第一層として速度 300 m/sec を有するもの (乾燥せる砂利又は砂層), 第二層は速度 1300 m/sec (水を含める砂利及び砂の互層) [或は 1400 m/sec (水を含める緩い砂層) 又場所によつては 1920 m/sec (水を含める緊つた砂利層)] 及び第三層は速度 2210 m/sec) 洪積層砂, 粘土及び砂利互層) より成ることを知る.

大井川に於て得た走時曲線は 320 m/sec (乾いた緩い砂利), 700 m/sec (層濕つた砂利層), 1600 m/sec (水を含める緊つた砂利層), 2100 m/sec (洪積層) 及び 3100 m/sec (第三紀層) の五種の彈性波傳播速度を表はす直線又は折線より成る.

以上各層の厚さはそれぞれ圖中に示してある.

之を要するに最上層 (速度 300 乃至 600 m/sec) の緩い砂或は砂利層は橋梁基礎としては十分なる地耐力を有するものとは言ひ難く, 構造物の基礎はこれ等の層より深いところに設置すべきである.

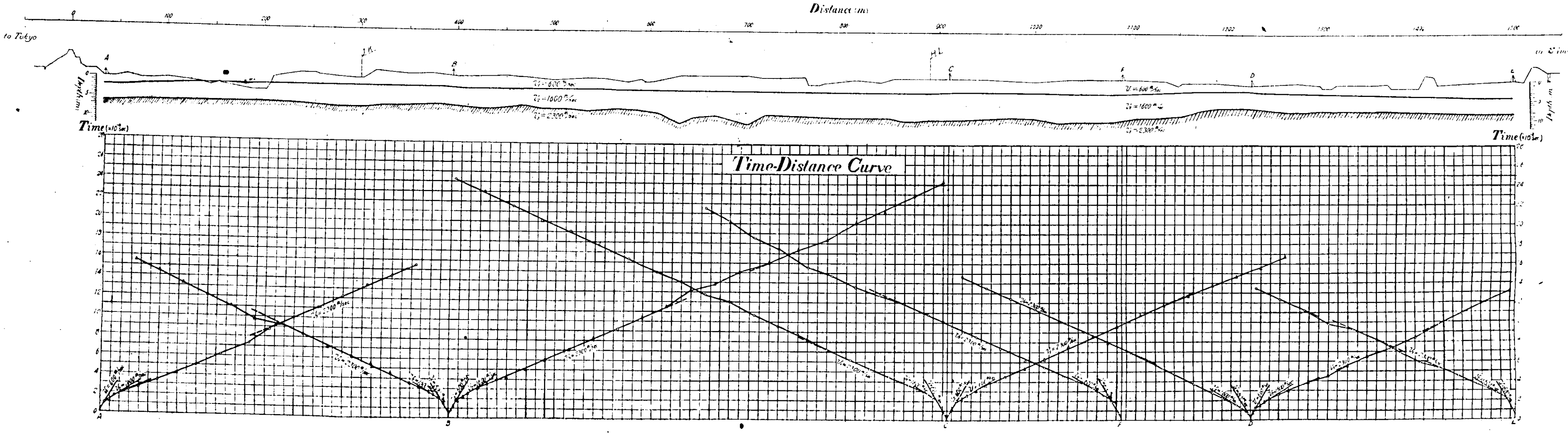

Fig. 1.

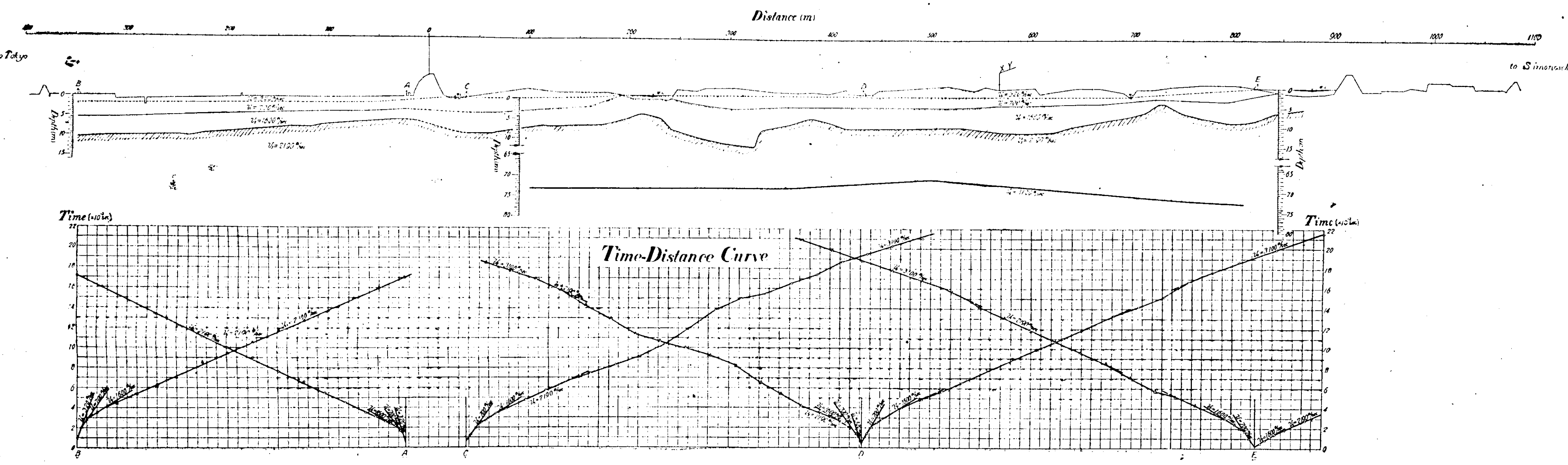

Fig. 4.

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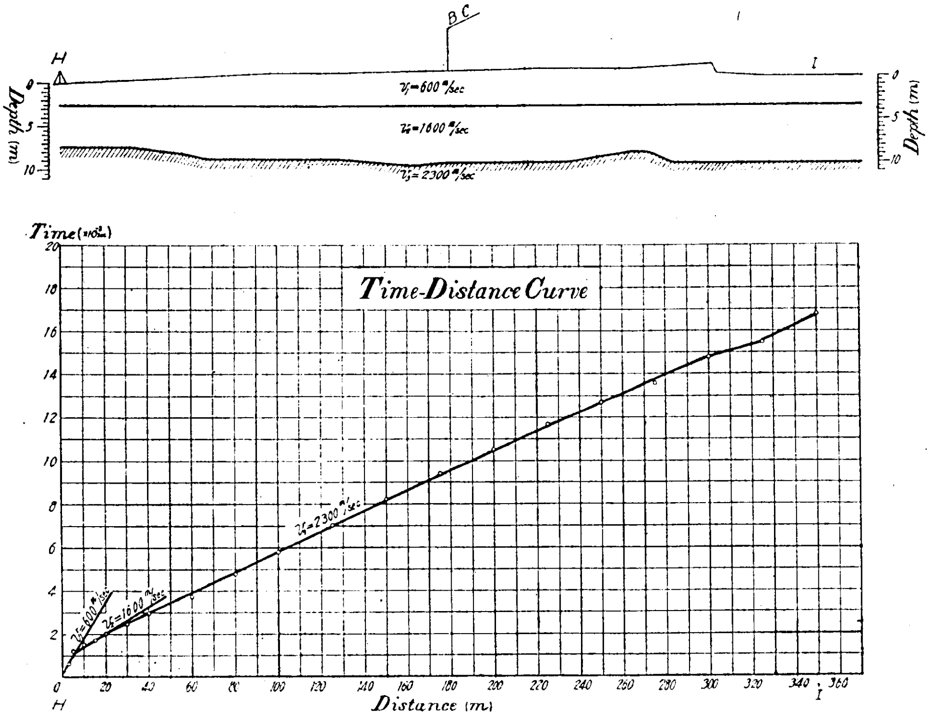

BC
H
I
v_1=600 m/sec
v_2=1600 m/sec
v_3=2300 m/sec
Depth (m)
Time (×10⁻² sec)
Time-Distance Curve
v_1=600 m/sec
v_2=1600 m/sec
v_3=2300 m/sec
Distance (m)

Fig. 2.

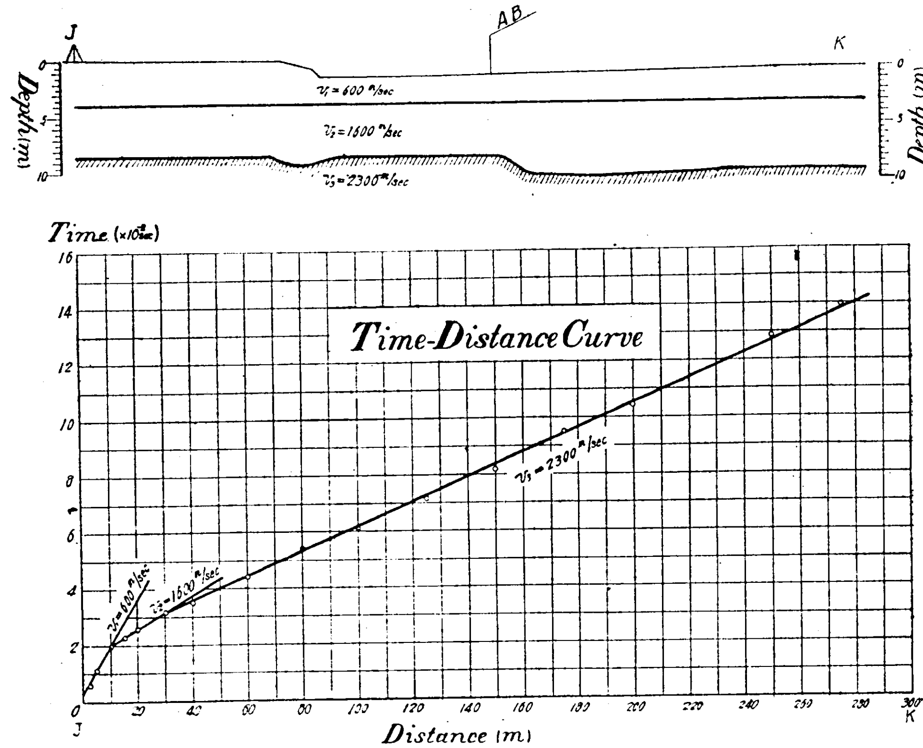
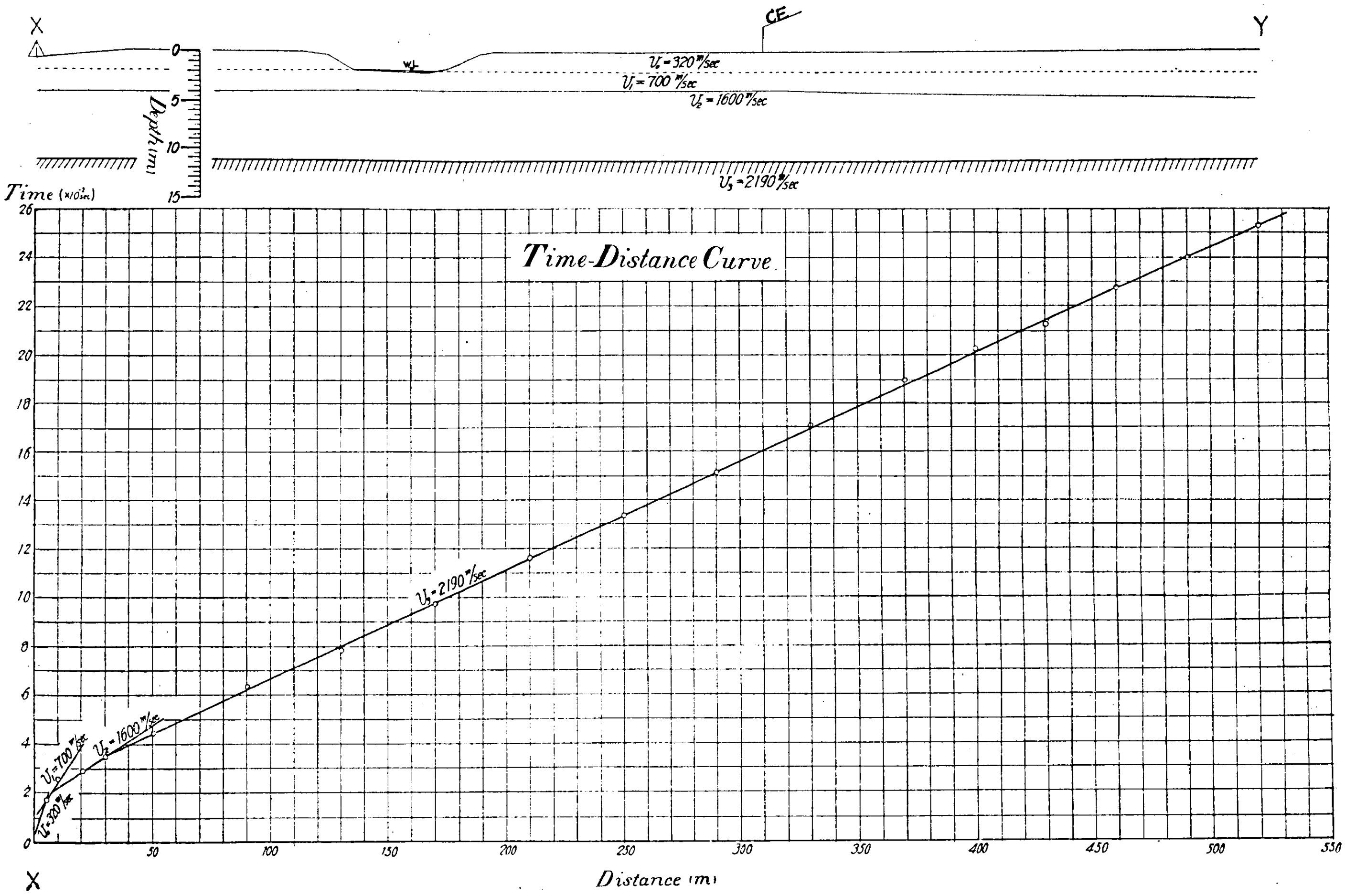

AB
J
K
v_1=600 m/sec
v_2=1600 m/sec
v_3=2300 m/sec
Depth (m)
Time (×10⁻² sec)
Time-Distance Curve
v_1=600 m/sec
v_2=1600 m/sec
v_3=2300 m/sec
Distance (m)

Fig. 3.



X
Y
CE
WL
Depth (m)
V_0 = 320 m/sec
V_1 = 700 m/sec
V_2 = 1600 m/sec
V_3 = 2190 m/sec
Time (×10⁻² sec)
Time-Distance Curve
Distance (m)
X

Fig. 5.

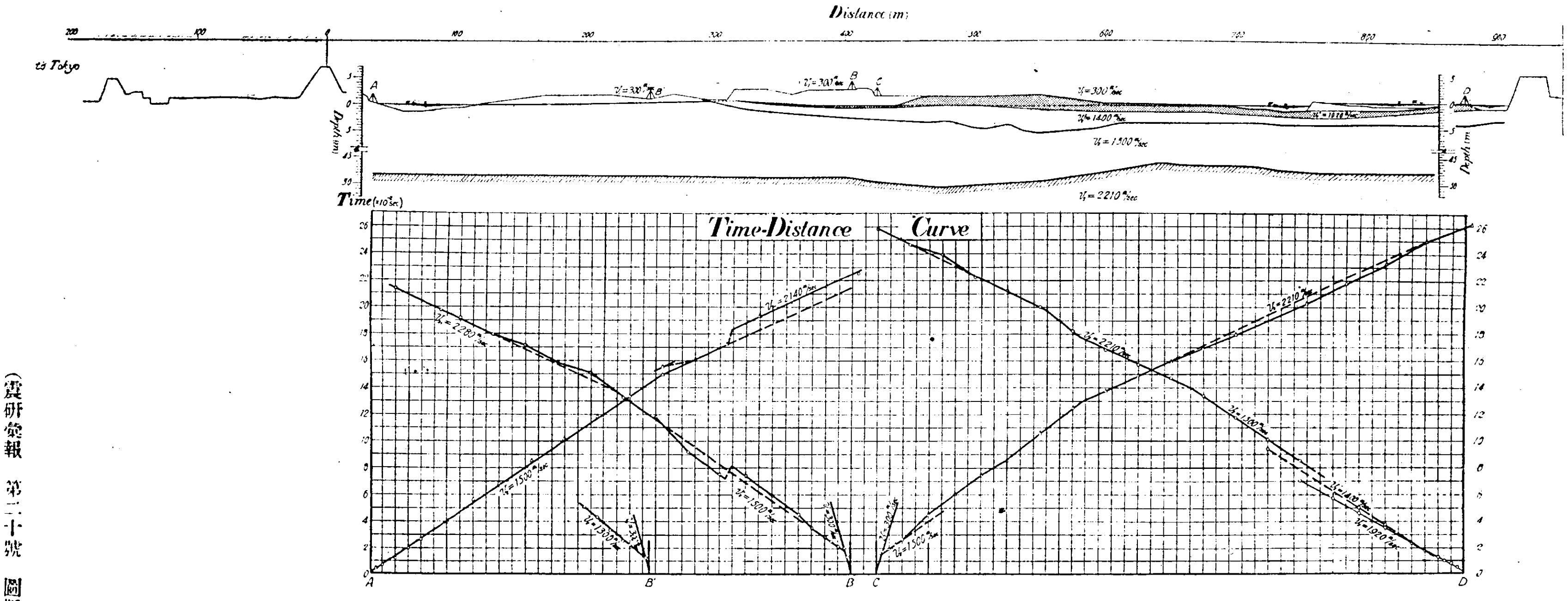

Distance (m)
to Tokyo
Depth (m)
Time (×10⁻³sec)
Time-Distance Curve
A
B'
B
C
D

Fig. 6.

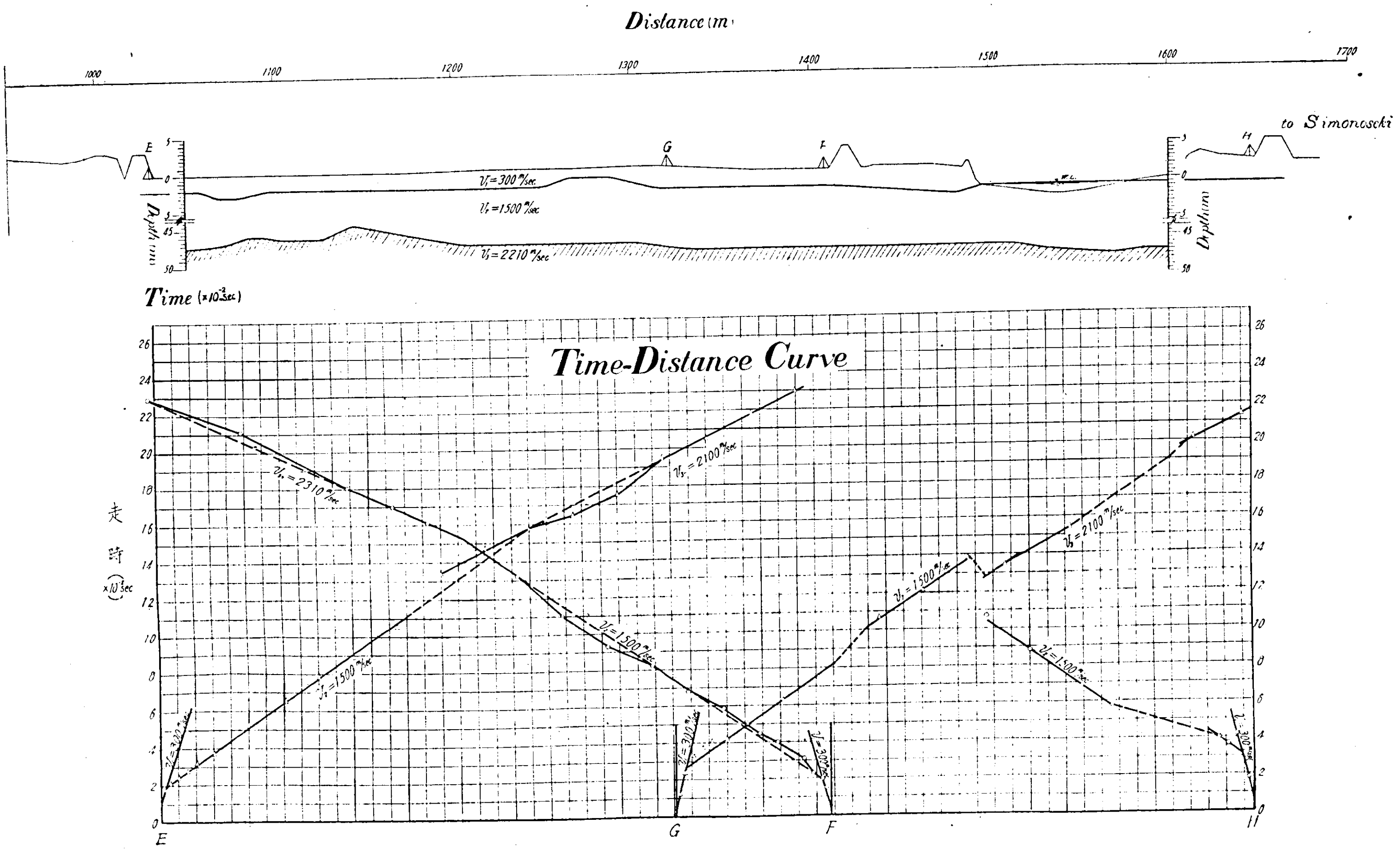


Fig. 7.

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