Proposed field soil testing device

CONFIDENTIAL

National Research Council

Associate Committee on Soil and Snow Mechanics

TECHNICAL MEMORANDUM NO. 1

PROPOSED FIELD SOIL TESTING DEVICE

Summary

A description of a proposed testing device for determining the trafficability of soils by A.F.Vs, with a brief discussion of its use, issued in advance of trials of an actual model of the device in view of the urgency of the relevant problem.

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(A contribution from the Directorate of Vehicles and Small Arms)

(1) The urgent need for a reliable and simple device for testing the properties of soils in place, in relation to their trafficability, is one of the main impressions formed from a study of the records of both British and U.S. "Mud-Crossing Committees" by those in Canada studying the same general problems. This general impression was emphatically confirmed during a recent visit to the U.S.A., on behalf of the Canadian Committee. Interest in this specific problem was encountered in discasssions with representatives of U.S. Ordnance, U.S. Engineer Board, U.S. Navy and British Army Staff (Detroit).

(2) Accordingly, and in view of the immediate urgency of this problem from the naval and military points of view, the matter had been discussed and studied in Ottawa. A field testing device has, in consequence, been designed by Captain M. G. Bekker of the Directorate of Vehicles and Small Arms. Captain Bekker was one of the party which visited the U.S.A. in June, 1945; his interest in the general question of tracked vehicle design is of long standing. Normally a pilot model of the device would have been made up in Canada and fairly thoroughly tested before the preparation of any descriptive memorandum, such as this. The urgency of the problem, however, has led to the preparation and circulation of this note in order to introduce the device to others interested at the earliest time practicable, in case the device may point the way to a solution of the immediate problem.

(3) The objective associated with the military use of field soil testing devices is to obtain a relatively simple means of determining the soil conditions in any particular area before the crossing of this area by A.F.Vs, in such a way that the trafficability of the area (in relation to the A.F.Vs to be used) can be determined in advance. All vehicles will subject the soil of an area they are to traverse to vertical loading, due primarily to the weight of the vehicle, and to horizontal loading, due to the development of resistance in the soil to the tractive force of the vehicle. The exact state of stress in the soil is complex. Essentially, however, it is dependent upon the two types of loading mentioned, resistance of the soil to the combined loading being provided by its shear strength.

(4) Field testing devices, details of which have been studied, can be grouped as follows: field shear testing mechanisms, penetration devices, and a combination of these two types. All the field shear testing instruments so far studied are either too cumbersome, or too elaborate for military use. In general they measure soil shear strength near the surface, without the application of a vertical load. The penetration devices, particulars of which are available, subject the soil being tested to a vertical load by various means. The use of a conical point introduces, indirectly, a degree of horizontal loading but the vertical and horizontal loadings are clearly interdependent. The British "vane-stick" does combine the ideas of penetration into the soil and then a horizontal movement which induces shearing stresses in the soil.

(5) Many of these devices are of great interest; doubtless they have been and still are proving to be of great use in practice. It seems probable, however, that accurate correlation between the results of field tests by these devices and the actual trafficability of the soil which was tested may be difficult to achieve. If so, the difficulty would appear to be due to the "scale effect" (as, for example, between a small cone and a wide tank track) coupled with the fact that the various devices do not subject the soil to the two independent types of loading caused by vehicle operation. The closest approach to this desideratum is given by the British vane-stick but, in the form so far publicised, no provision is made for vertical loading. Mr. Maurice Cilley has pointed out that it would not be difficult to introduce such vertical loading into the operation of the stick. Even if this were done, however, the horizontal motion obtained still differs considerably from that induced under vehicles in motion.

(6) In an attempt to meet these several difficulties, Captain Bekker has designed the apparatus shown in Figure One. (A print from the full-scale drawing will accompany most copies of this memorandum so that details of the proposed mechanism can the more easily be studied). The device is fitted with two similar foot-plates, shaped to give the effect of grousers, one left-handed and the other right-handed. It will be appreciated that the size and shape of these plates can be changed as desired, but it is intended that they shall be of such size and shape that the soil action under them is comparable to that under a track tread. Of even greater importance is the correlation of the vertical unit pressure on the foot-plates with the maximum unit pressure characteristic of the given type of A.F.V. These plates can be forced into the ground to be tested under any unit pressure which may be desired, recorded on one of the vertical scales, the other vertical scale

recording the sinkage thus produced. When sinkage has taken place, the two foot-plates may be moved horizontally apart, the force required to move the plates being indicated on the horizontal dial. The maximum value of this force would be recorded. In this way, the "slippage" of a loaded track tread may be simulated.

(7) Figure Two shows, diagrammatically, how the device could be operated. Two operators are indicated; they would stand on light-weight plates to which would be attached light metallic tubes, securing the casing of the mechanism. Once the latter was in place, penetration would be obtained by turning one of the hand-wheels, then horizontal movement by turning the other. Automatic stops could be arranged on the scale and dial so that readings could be taken after the device had been removed from the test location, if desired.

(8) For each test with the instrument, three values would be obtained -- sinkage (S), vertical loading (V), and maximum horizontal resistance (H). Theoretical soil studies suggest that the dimensionless ratio (H/V) will be found to vary consistently with S. Experimental studies have already shown that the dimensionless ratio (Movement Resistance/Weight) also varies consistently with S. Correspondingly, track slippage is known to vary consistently with movement resistance and so with S for any given type of ground. These relations are indicated generally in Figure Three. It is to be noted that the shape of the $\left(\frac{H}{V} \text{ to } S\right)$ curves is not yet known. By means of the proposed instrument, it would be relatively easy to develop these curves for different types of ground. There is already available some information on the interrelation of movement resistance and slippage with sinkage. It is understood that work on this aspect of the problem is currently in progress. It seems probable that it should be possible so to interrelate two or three of these sets of relationships (shown in Figure Three) that readings with the proposed instrument could be used to give, directly, an indication of movement resistance and/or slippage to be expected for the ground tested, for any given A.F.V. Another matter which will have to be investigated, if only in a general way for immediate use, is the effect upon sinkage of the scale difference between the proposed foot-plates and the treads of actual A.F.Vs.

(9) Admittedly, before such a device as is suggested could be used in action, careful experimental correlations would have to be established between its results and the performance of individual vehicles over different types of ground. This work should not be very involved or time-consuming. It would seem that, even with the simplest kind

of bog-stick some such correlation would also be essential.

There is the further objection that, as now shown, the device needs two men for its operation. The accompanying drawings show the first design to be committed to paper. If the basic idea is found to be sound, and usable, it is almost certain that a simpler method of operation can eventually be devised.

(10) It must again be emphasized, in conclusion, that this note and the accompanying drawings are being circulated for discussion only. The basic idea appears to be worthy of careful study, the more especially in view of the critical character of the problem with which it deals. The Committee will welcome comments and suggestions regarding the proposed device and requests that they be submitted at the earliest possible opportunity.

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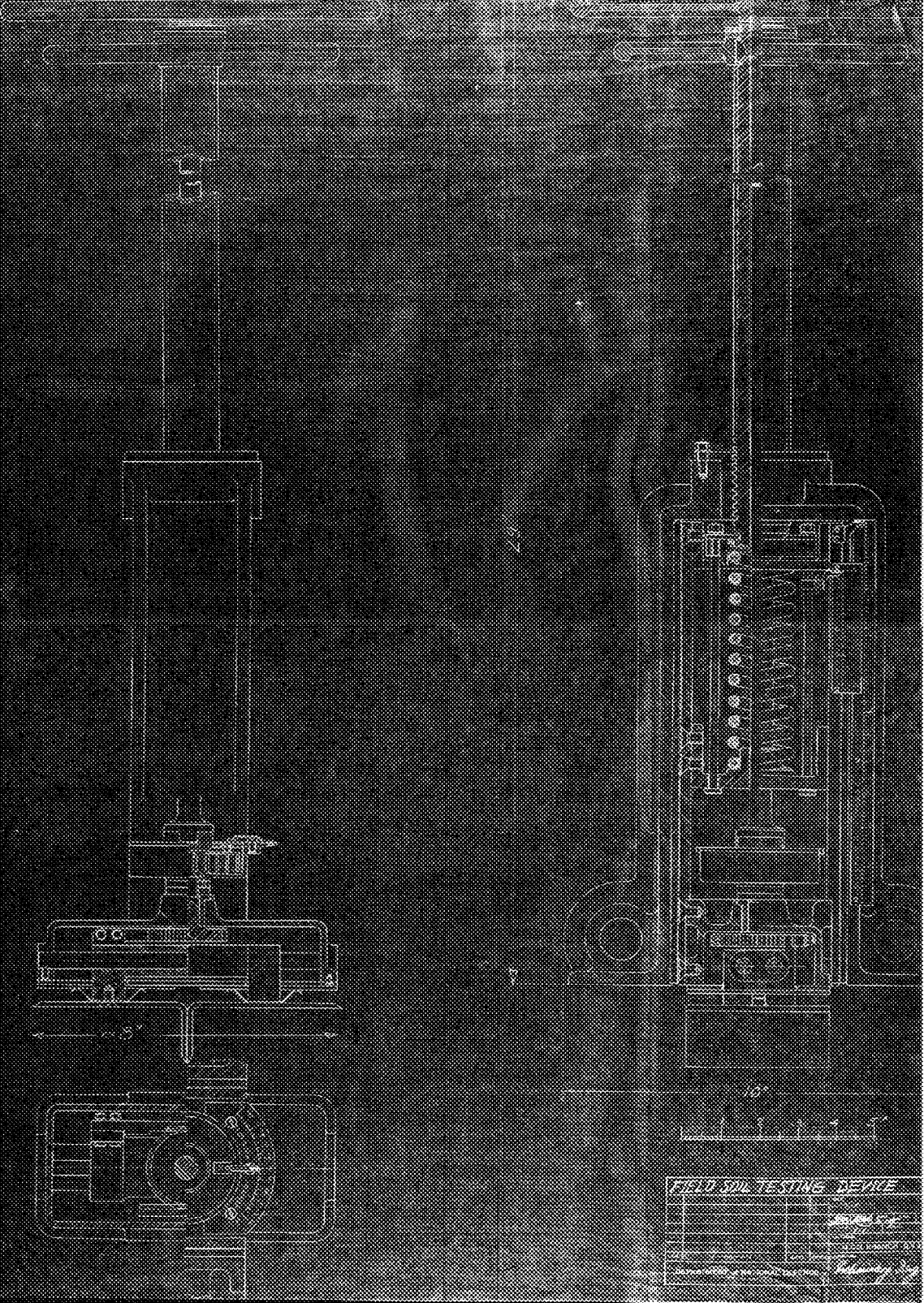
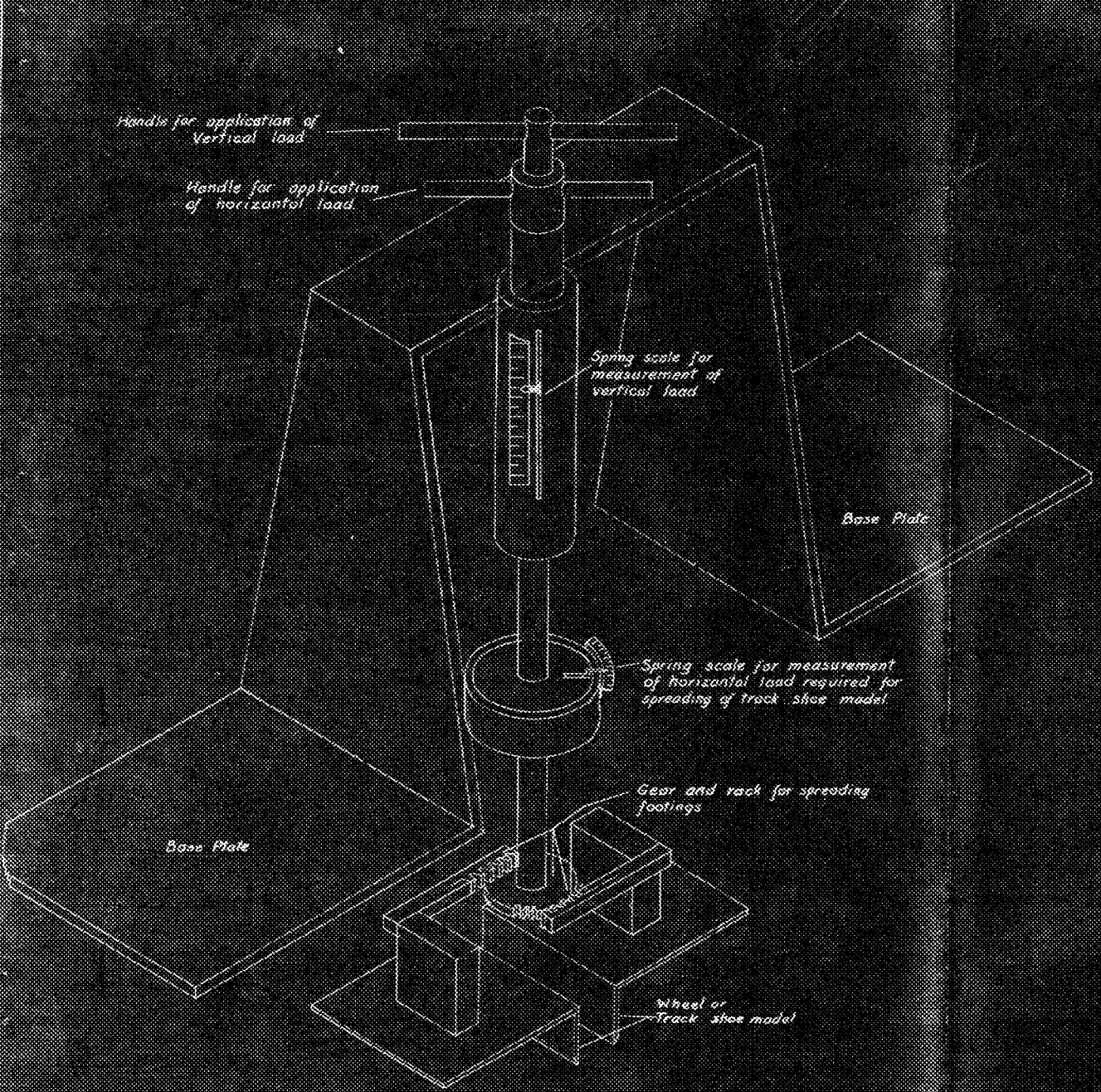
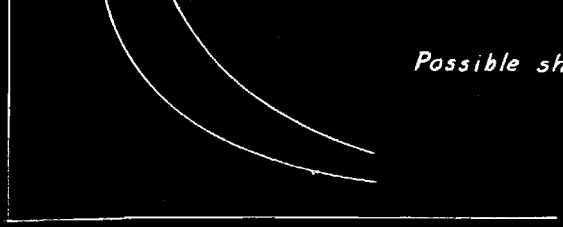

FIELD OIL TESTING DEVICE



FIELD SOIL TESTING DEVICE

$\frac{H}{V}$

Possible shape of curves

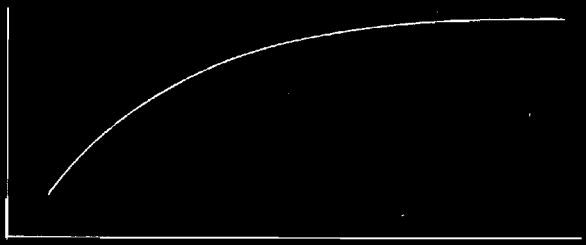


S

$\frac{MR}{W}$

S

Slippage



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* Blueprint of Figure One sent to all marked.