Sept. 13, 1960 F. J. CONVERSE 2,952,193

SOIL COMPACTING MACHINE

Filed Sept. 9, 1953

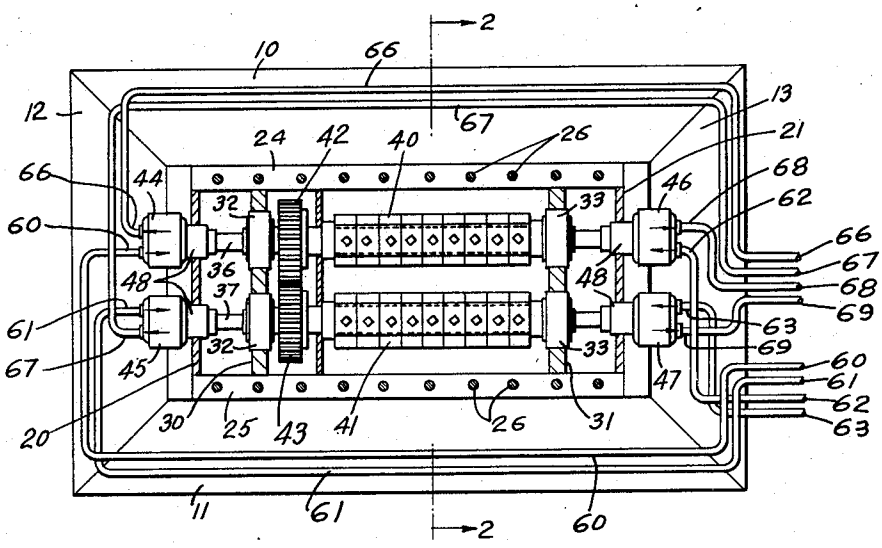


Fig. 1.

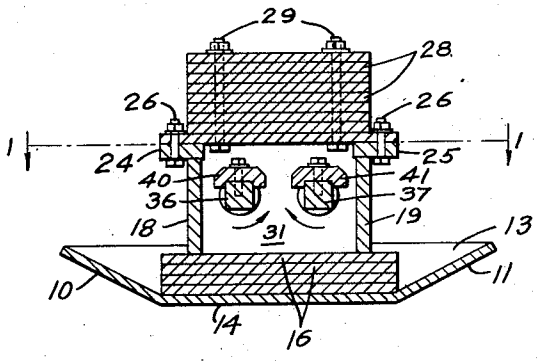


Fig. 2.

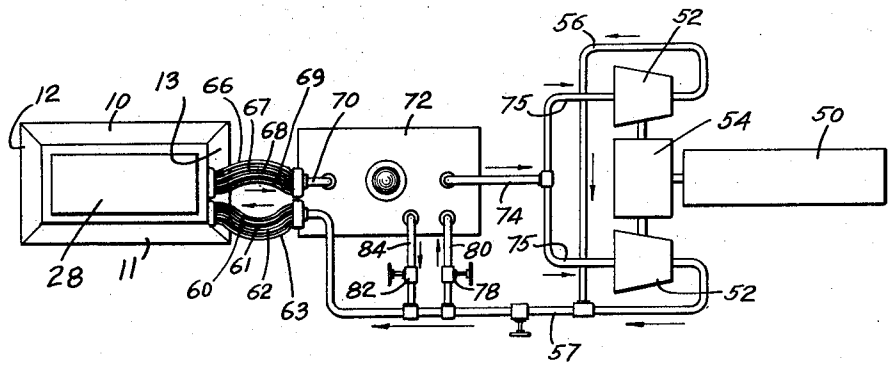


Fig. 3.

INVENTOR.
Frederick J. Converse.
BY D. G. Draper
A. R. McCandy
ATTORNEYS

United States Patent Office 2,952,193 Patented Sept. 13, 1960

2,952,193

SOIL COMPACTING MACHINE

Frederick J. Converse, San Marino, Calif., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Filed Sept. 9, 1953, Ser. No. 379,317

1 Claim. (Cl. 94—48)

This invention relates to a machine for compacting soil and the like, and more generally to a machine for impressing upon a structure rhythmic forces of relatively large magnitude and low frequency.

Soil compaction machines are used in the construction of roads, airport runways, earth-filled dams, and the like, to increase the structural bearing capacity of the soil. The present machine may be used for other purposes, as in the study of structural vibrations.

In comparison with standard soil compaction equipment now in general use, this machine accomplishes its purpose, not by virtue of its dead weight alone, but rather by the correct utilization of dynamic forces of controllable frequency and magnitude. In particular, the machine is most effective as a soil compaction device when operated at the resonant frequency of the composite system consisting of the vibrator and the soil mass on which it rests. The resonant frequency is primarily a function of the type of soil being treated, although it is to some extent influenced by the size, shape, and weight of the vibrator, and by the magnitude of the dynamic forces produced by the vibrator. The resonant, or optimum, frequency of vibration for soil compaction may be identified as that frequency at which maximum vertical displacement of the vibrator occurs under the influence of a constant dynamic force.

An object of the invention is to provide an improved machine for impressing upon soil or other structure a series of resonant vibrations.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description.

Fig. 1 is a plan view of a device embodying the invention, with the upper portion cut away on a line corresponding generally to line 1—1 of Fig. 2;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1; and

Fig. 3 is a diagrammatic view of the driving mechanism for the vibrator.

In the form of the invention shown by way of example in the drawing, the machine comprises a base in the form of a sled or stone-boat having upwardly inclined sides **10**, **11** and ends **12**, **13**, with a bottom **14**. All these elements may be formed integral with each other, as shown. Mounted on bottom **14** are a plurality of plates **16**, of cast iron or other heavy material, secured together in any suitable way and forming the lower dead weight of the machine. Mounted on and secured to the plates **16** is a rigid box frame comprising sides **18**, **19** and ends **20**, **21**. Secured as by welding to the upper edges of sides **18**, **19** are beams **24**, **25**, to which are secured, by bolts **26**, a plurality of plates **28**, similar to plates **16** and forming the upper dead weight of the machine. Plates **28** may be secured together by means such as bolts **29**.

In cross plates **30**, **31**, extending between side members **18**, **19**, are mounted bearings **32**, **33** in which are

journaled two longitudinal shafts **36**, **37**, preferably formed of rectangular cross section at their midsection and having secured thereto a plurality of eccentric weights **40**, **41**. The shafts are interconnected by two intermeshing similar spur gears **42**, **43** keyed to the respective shafts and causing them to rotate at the same speed, though in opposite directions.

A plurality of hydraulic gear motors **44**, **45**, **46**, **47** are mounted in the end members **20**, **21**, and are connected to the opposite ends of shafts **36**, **37** by couplings indicated at **48**. Motors **44** and **46** are connected to rotate in the same direction, say counterclockwise, so as to turn shaft **36** in a counter-clockwise direction, as shown in Fig. 2. Motors **45** and **47** are connected to rotate in the same direction, with respect to each other, but turn their associated shaft **37** in a clockwise direction. While the power required to operate the shafts **36** and **37** may be supplied by any suitable speed-controlled power source such as an internal combustion engine mounted on the sled itself, a power takeoff from the pulling tractor, or other suitable mechanical or electrical drives, it has been found that the plurality of fluid motors specified above furnish the greatest power in the least space with the maximum and simplest speed or frequency control. Regardless of slight differences in the capacity of the various motors, shafts **36** and **37** are constrained to rotate in opposite directions and at the same, synchronous speed due to the action of the similar spur gears **42**, **43**. Accurate speed control is effected by means of controlling the speed of the prime mover or engine **50** in steps with a fine control afforded by the simple operation of flow control valve **78**. Thus, with valve **78** closed, as the engine **50** is speeded up, say 100 r.p.m., pumps **52** are speeded up and the volume of displacement fluid moved by the pumps is increased. Since the speed of the hydraulic motors **45**, **46**, **47**, and **48** is a function of the volume of displaced fluid delivered by the pumps, the motors speed up as do the shafts **36** and **37** to which they are attached. If the frequency of oscillation so produced is now slightly higher than that desired, by opening valve **78**, a portion of the increased volume of fluid is diverted into the low pressure reservoir tank **72** and the hydraulic motors are slowed down sufficiently to produce the desired frequency of oscillation.

The apparatus for furnishing pressure fluid to motors **44**, **45**, **46**, **47** is indicated in Fig. 3, and is preferably mounted on a tractor which may be used to draw the compacting machine over the soil, or on a trailer drawn by such tractor. The apparatus comprises an engine **50** which is connected to two hydraulic pumps **52** through a gear box **54**. The pressure fluid is conducted from pumps **52** through conduits **56**, **57** and flexible branch conduits **60**, **61**, **62**, **63** to motors **44**, **45**, **46**, **47**. The exhaust fluid from the motors is returned through flexible branch exhaust conduits **66**, **67**, **68**, **69** and conduit **70** to a reservoir **72**, whence it is returned through conduits **74**, **75** to the pumps **52**. The arrows in Figs. 1 and 3 indicate the direction of fluid flow through the various conduits with which they are shown. Thus, in Fig. 1, the small arrows shown on motor **44**, for example, indicate the inlet of fluid from conduit **60** and the exhaust or outlet fluid flow from the motor to the conduit **66**. In Fig. 3, the use of the fluid flow indicating arrows is obvious.

The reservoir **72** may include an air dome to minimize fluctuations of pressure in the fluid, but its chief purpose is to provide storage capacity for the fluid and thereby prevent overheating. Inflow of fluid thereto from conduit **57** is controlled by a flow control valve **78** in a connecting conduit **80**, and return flow to the conduit **57** is controlled by a relief valve **82** in a conduit **84**.

The arrangement of the shafts **36**, **37** with their at-

tached eccentric weights is such that the centrifugal forces produced are additive in the vertical direction and mutually cancel in all other directions. The magnitude of these dynamic forces is directly proportional to the mass of the eccentric weights and to the square of the frequency of rotation. In other words, as shafts 36 and 37, with their eccentric weights 40 and 41, are rotated, the soil compacting machine vibrates up and down at a frequency of oscillation dependent, of course, upon the speed of rotation of shafts 36 and 37.

In operating the vibrator unit as a compaction device for the densification of soils, the frequency of oscillation is precisely adjusted until the resonant frequency of the "vibrator-soil mass system" is attained. This frequency should be maintained at all times during the compaction operation as the vibrator is pulled over the ground surface by a tractor or other prime mover.

In determining the resonant frequency of the system, the speed of shafts 36, 37 is varied until the maximum peak-to-peak displacement occurs. Such maximum may be determined in various ways:

(*a*) By means of a vibration "pickup" attached to the vibrator and producing electrical impulses which record the displacements on an oscilloscope or in ink on a moving paper.

(*b*) By observation. An operator in the field soon learns to determine the maximum vibration by watching the vibrator as he changes speed.

(*c*) A black horizontal line is drawn on a white surface and attached to the vibrator. The line appears to be a gray band when vibrated. When the band appears to have maximum width, the machine is in resonance.

The value of the frequency may be determined by observation of the graph from the "pickup" mentioned in (*a*) above, or by a tachometer or revolution counter. A field method is to tow the vibrator at a constant known speed and count the ripples formed in the surface of the soil in a given distance.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

What is claimed is:

A vibrating machine for compacting soils or similar materials at the resonant frequency of vertical oscillation of the system consisting of said machine and the material being compacted thereby, comprising, in combination:

an oblong stoneboat-like base member having a substantially flat bottom;

means to tow said base member over the surface of the material to be compacted, said base member having a relatively long longitudinal axis in the direction of tow and relatively shorter transverse axis;

lower oblong ballast plates rigidly secured to the upper flat surface of said base member;

a pair of transverse vertical cross plates rigidly secured to the said lower ballast plates;

bearing means carried by said transverse cross plates;

upper oblong ballast plates rigidly but detachably secured adjacent to the upper surfaces of said transverse cross plates whereby the number of ballast plates may be varied to control the fixed weight of said machine;

a pair of parallel shafts journaled in said bearing means, said shafts having a rectangular cross-section for the major portion of their lengths intermediate of said bearings and said shafts being disposed equidistantly from said longitudinal axis and said base member;

a plurality of similar eccentric weights detachably secured to corresponding sides of said rectangular shaft portions;

gear means operatively connecting the shafts for synchronous rotation in opposite directions;

speed controllable driving means supported by said base member for rotating said shafts, said speed controllable driving means comprising two sets of counter-rotating fluid motors, the first set of said fluid motors being connected to the ends of one of said pair of shafts and the second set of said fluid motors being connected to the ends of the other of said pair of shafts whereby the torque to rotate said one shaft with its associated plurality of distributed eccentric weights is furnished independently of the torque supplied to rotate the said other shaft with its associated plurality of distributed eccentric weights, said shafts being rotated in opposite directions but at the same speed; and

means for infinitely varying the speed of said speed controllable driving means whereby the frequency of vertical oscillation of said machine as a function of its weight and the dynamic forces resulting from the rotation of said plurality of adjustable eccentric weights may be adjusted to resonance with said system.

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