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[54] VIBRATION METER SYSTEM FOR VIBRATORY COMPACTION MACHINES

[75] Inventors: **Edwin J. Haker**, Elm Grove; **Norman L. Peterson**, Wauwatosa, both of Wis.

[73] Assignee: **Rex Chainbelt Inc.**, Milwaukee, Wis.

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[52] **U.S. Cl.** **404/117**, 73/71.4
[51] **Int. Cl.** **E01c 19/38**
[58] **Field of Search** 404/117, 84, 133; 73/71.4, 71.5, 71.6, 71.7; 335/275, 276

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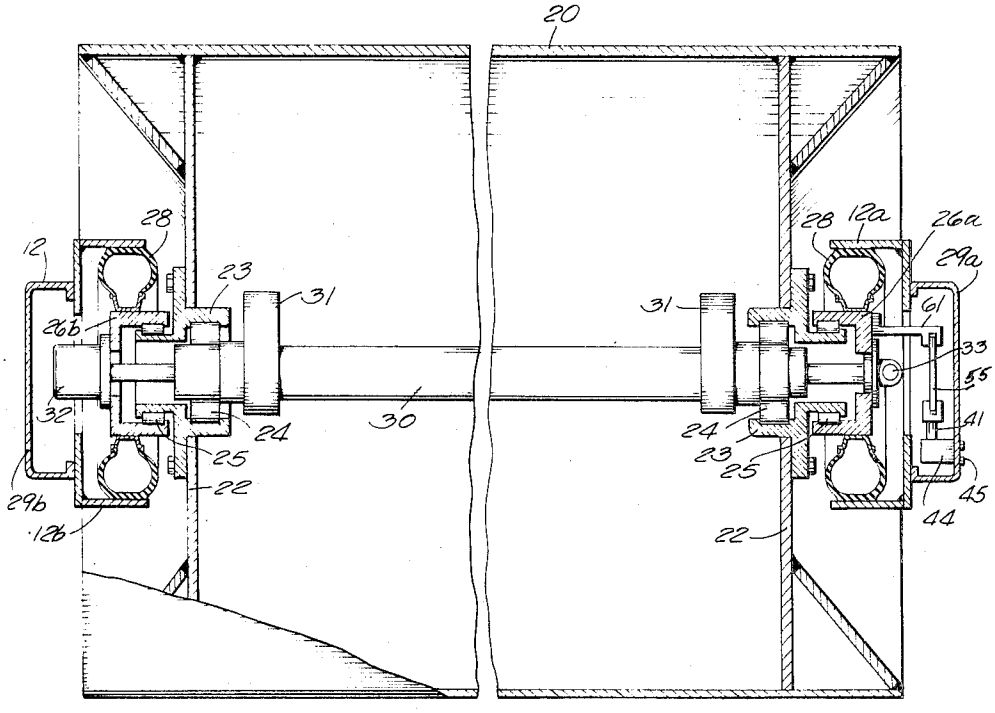
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Primary Examiner—Ramon S. Britts
Assistant Examiner—Thomas J. Holko
Attorney—Ernst W. Schultz et al.

[57] **ABSTRACT**

A soil and road-grade compaction machine includes a heavy rigid frame, a roller having a power driven eccentric weight rotating about the roller axis, and cushion means which allows the roller to vibrate with only nominal movement of the frame. The vertical component of the movement of the roller relative to the frame or "bounce" of the roller operates an electric current generator having its output inductively attenuated and then rectified and measured by a meter which indicates any increase or decrease in the bounce of the roller in relative terms.

8 Claims, 5 Drawing Figures



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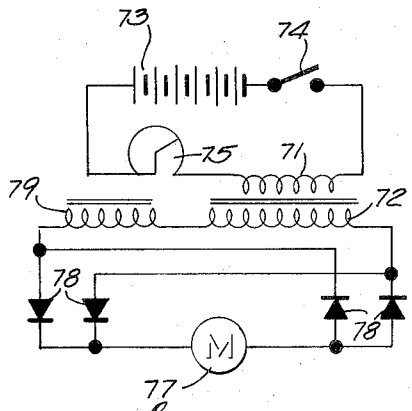
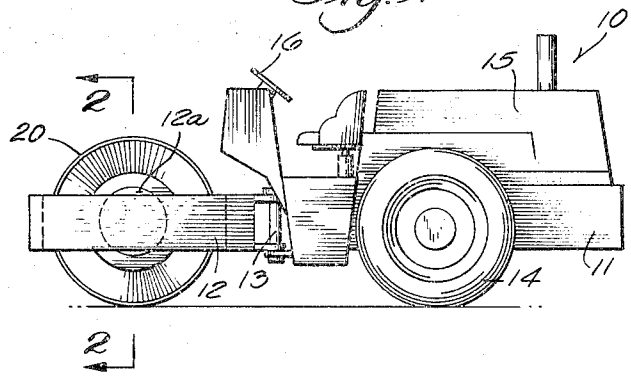


Fig. 5

Fig. 1



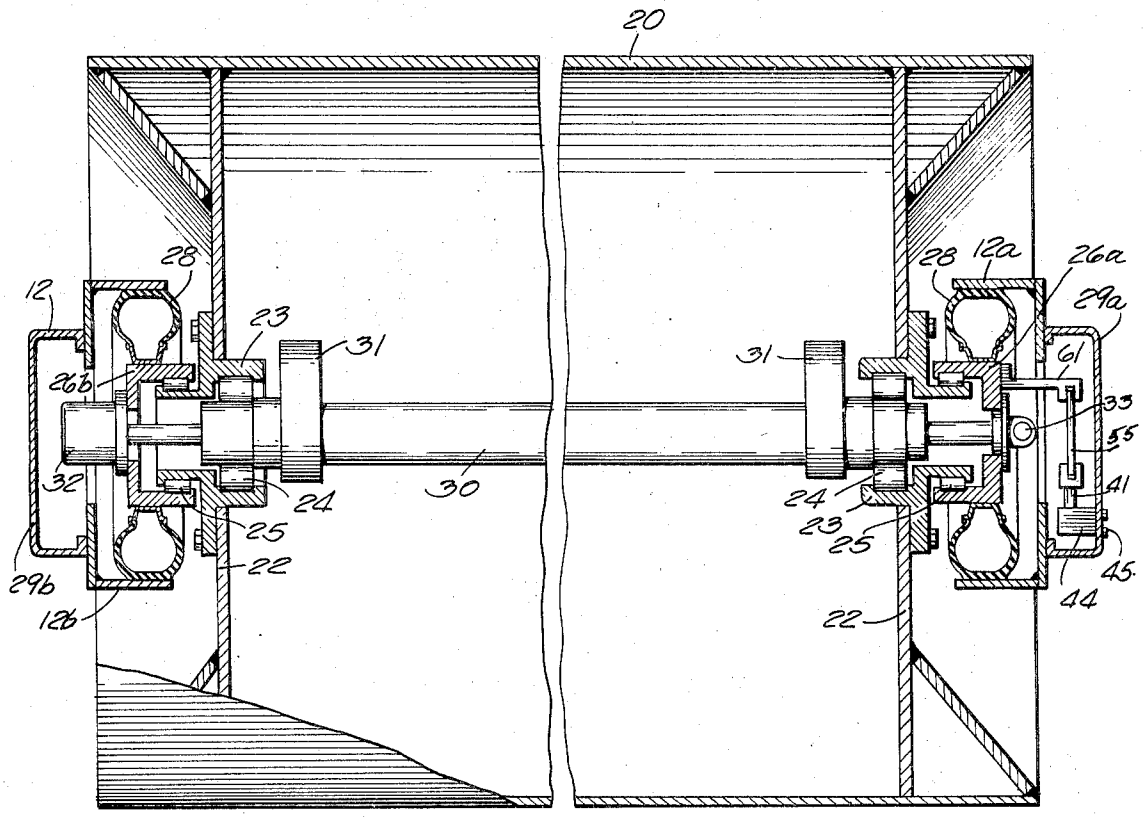


Fig. 2

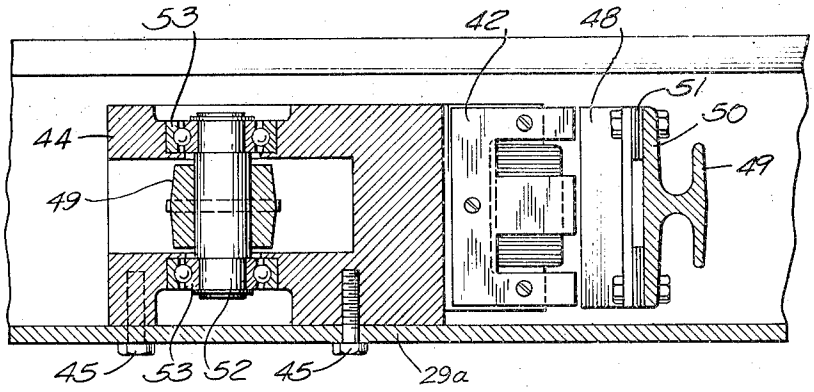

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Fig. 4

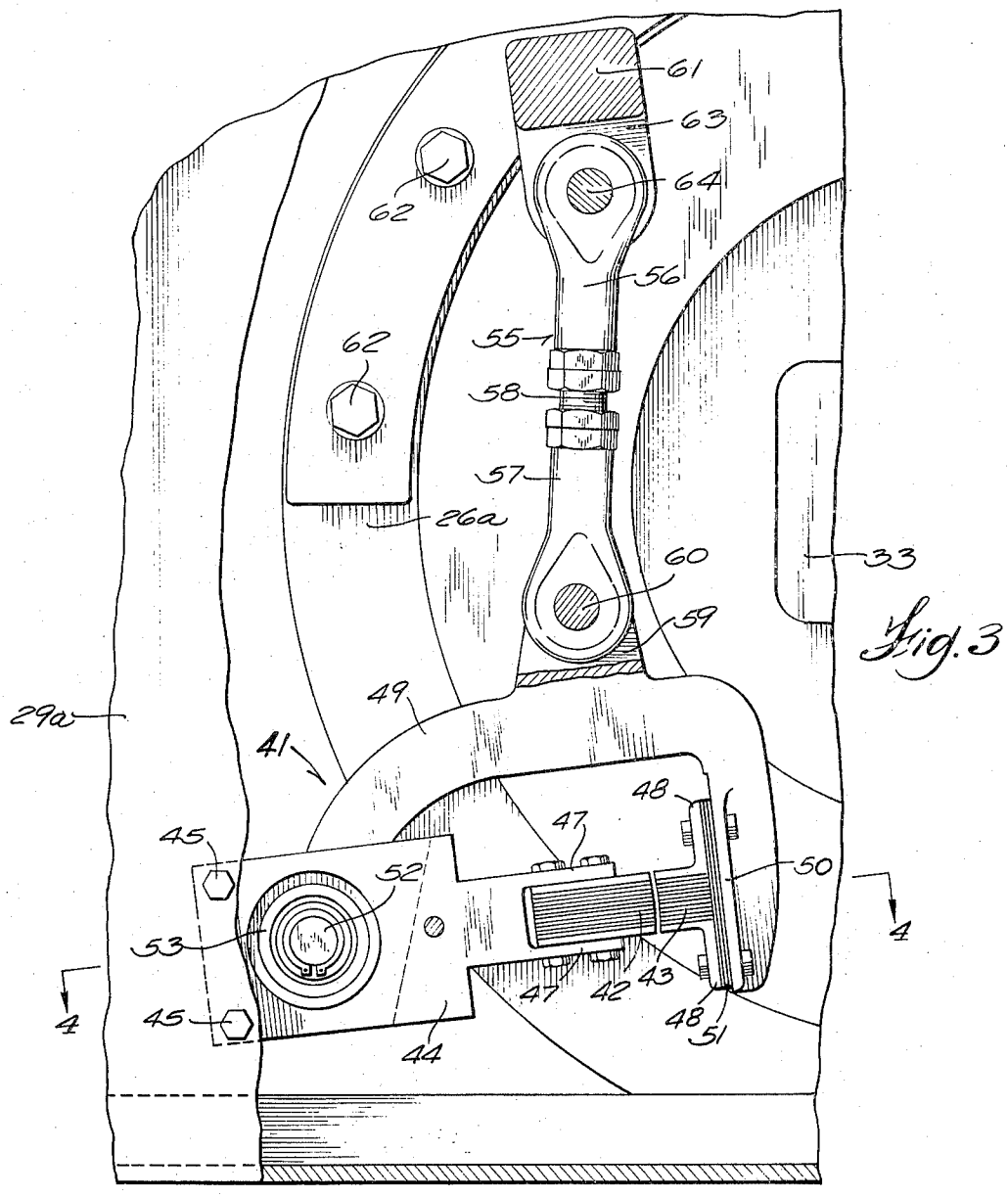

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Fig. 3

VIBRATION METER SYSTEM FOR VIBRATORY COMPACTION MACHINES

BACKGROUND OF THE INVENTION

The field of the invention is essentially soil compaction in preparation for the making of roadways.

The prior art includes vibratory rollers of the type which are adapted to move at relatively high speeds over the grade under preparation. As distinguished from rollers which are merely weighted to effect compaction, these rollers are vibrated vertically to effet compaction. However, their effectiveness requires that they vibrate at or near the frequency of ground resonance which changes as the machine traverses different types of soil or fill or with each successive pass over the same soil or fill. Prior art devices carried by the machine frame to indicate vibration amplitude of the frame are not effective with compaction machines of recent development having greatly increased frame weight and mass and improved isolation such that the frame, the engine and the operator's platform vibrate very little.

The prior art includes devices which indicate "amount" of vibration but does not include reliable devices capable of indicating amplitude of vibration as such and which will survive the millions of cycles of vibration required generally in the frequency range of 300 to 1,800 cycles per minute or 5 to 30 cycles per second.

SUMMARY OF THE INVENTION

The output of a field-supplied alternating current generator having an oscillating armature is connected by an inductive reactance through rectifiers to a galvanometer which indicates the amplitude of armature oscillation generally independently of oscillation frequency at least within the range of its application. The generator stator is carried by the relatively non-vibrating frame of a soil compaction machine and the generator armature is driven by a vertical link connected to the vibrating element of the machine. The meter indicates directly any increase or decrease in the amplitude of vertical vibration of the element, which change may be due to a change in ground resonance or the operator's change of vibration frequency toward or away from the frequency of ground resonance. Such indications thus allow the operator at any time to quickly "find" or confirm the vibration frequency which provides maximum effective compaction while the machine is in operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a vibratory compaction machine with some parts shown with broken lines;

FIG. 2 is an enlarged section taken on line 2—2 of FIG. 1 and through the axis of the roller;

FIG. 3 is a side elevation of the generator and includes a part of the frame and a part of the vibrating element to which the generator stator and armature are connected;

FIG. 4 is a section taken on line 4—4 of FIG. 3; and

FIG. 5 is a diagram of the windings of the generator and of the input and output circuits.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The self-propelled vibratory roller 10 shown in the drawings includes the articulated frames 11 and 12 which are connected by the pin 13 for relative pivotal steering movement about a central vertical axis. The rubber tired wheels 14 support frame 11 which carries the engine 15 and the operator's control station 16.

The rectangular frame 12 surrounds the compaction roll 20 and is of U-shaped section. A shown in FIG. 2, the end discs 22 of roll 20 are provided with hubs 23 each having inner and outer bearings 24 and 25, respectively. Bearings 25 support the hubs 26*a* and 26*b* of the two cushion members 28 which support frame 12. For that purpose, each side member 29*a* and 29*b* of frame 12 is provided with a circular housing 12*a* in which the respect cushion member is securely pressed.

The shaft 30 carrying the eccentric weights 31 within roll 20 are rotatably supported by bearings 24. One end of shaft 30 is connected to the output shaft of the hydraulic motor 32 which is fixed to hub 26*b*. The other end of shaft 30 is connected to a drive line which connects the shaft and a tachometer, not shown, provided at the control station 16. The terminal housing 33 of the drive line referred to is secured to hub 26*a*.

An hydraulic system, not shown, includes a pump driven by engine 15, and a motor, not shown, which drives wheels 14. A hydraulic cylinder, not shown, connects the two frames 11 and 12 and is controlled by the operator to effect steering of the machine. Other conventional controls, not shown, allow the operator to control the speed and direction or travel of the machine and the speed of rotation of shaft 30 by motor 32.

A preferred form of the generator 41, as shown, may be provided by modifying a conventional transformer which includes primary and secondary windings on the center leg of a laminated core. Such a core is modified to comprise a stator 42 of an E section and an armature 43 in the form of an I section and which are separated by an arcuate air gap which has a geometric center in the central plane of the core and parallel to the cross-piece of the E section. The bracket 44 which supports the stator 42 is located within and secured by bolts 45 to the side member 29a of frame 12.

The stator 42 is clamped between the arms 47 of bracket 44 so that it is rigidly fixed with respect to frame 12. The armature 43 is clamped between the flanged members 48 which are bolted to the movable end of the lever 49. Lever 49 comprises a rigid, lightweight casting and is of an inverted U-shaped configuration.

In operation, roller 10 traverses the ground or prepared soil or fill whatever number of times may be needed to compact the soil to the depth and density required. For that purpose, motor 32 rotates shaft 30 at a speed selected by the operator which appears to provide maximum compaction. The isolation of the roll 20 from frame 12 allows the roll to move eccentrically and the vertical component provides the main compactive effort. Thus, under any given condition, maximum amplitude is considered to indicate the maximum compaction which can be accomplished. On soft ground, the maximum amplitude of the roll can be observed within a broad range which is very often entirely adequate. Obviously, it is desireable to be able to reach the required compaction with as few passes as required. However, and especially where the compaction requirement is difficult to achieve, on the second and subsequent passes, the optimum or critical speed of ec-

centric rotation is difficult to observe or detect by any means.

The present invention provides a well defined indication of relative changes in the amplitude of vertical vibration or bounce of the roll, even though the differences being compared are only small fractions of an inch.

The free end of lever **49** includes a flat plate **50.** Members **48** are bolted to plate **50** with a number of intermediate shims **51** as may be required. The opposite end of lever **49** is provided with projecting trunnions **52** which are supported in the bearings **53** carried by the bracket **44.** The axis of bearings **53** coincide with the geometric center of the arcuate air gap referred to and the shims **51** allow for adjustment of the air gap to a minimum practical width in the order of 0.006 and 0.010 inches.

The connecting link **55** comprises upper and lower ball and socket type rod ends **56** and **57,** the threaded connecting member **58** and suitable lock nuts, as shown. The lower rod end **57** fits between two spaced lugs of lever **49.** The lug **59** and the other lug which is broken away as shown in FIG. **3** carry the removable pin **60** which extends through the lower rod end **57.** The upper rod end **56** fits between the two spaced lugs of the bracket **61** which is fixed by the bolts **62** to the hub **26***a* of one of the cushion members **28.** The lug **63** and the other lug which is broken away, carry the removable pin **64** which extends through rod end **56.**

The mechanical operation of generator **41** is effected by the connection of armature **43** with hub **26***a* through link **55** which is vertically disposed so that the vertical component of roll movement or "bounce" oscillates armature **43** about the axis of bearings **53** as will be described hereinafter.

Stator **42** includes two windings and as has been mentioned, they comprise the field and output windings **71** and **72,** respectively, as shown in FIG. **5.** The field winding **71** is connected in series with the source of D.C. voltage **73,** the switch **74** and the potentiometer **75.** The D.C. voltage source may, of course, be that provided for engine **15** and switch **74** may be the ignition switch or a separate switch. Potentiometer **74** generally requires a single adjustment to place the output of generator **41** within the range of the D.C. meter **77.**

Meter **77** may be a simple moving-coil (D'Arsonval) device with a single needle indicator or lamps, not shown, and is located at control station **16.** The diodes **78** are arranged to rectify the alternating current of the output winding **72** of the generator **41.** However, the value of inductance **79** which is connected in series with winding **72** is critical and is selected to attenuate the generator so that the voltage and current to meter **77** is reduced proportionate to any given increase in the frequency of the drive output of the generator. Additionally, of course, inductance **79** presents a high impedance to the small "miscellaneous" motions transmitted by link **55** to armature **43.** In the operation of generator **41,** each armature cycle reduces and restores the flux path across the air gap which in turn reduces and restores the magnetic field of winding **71** and generates a current in winding **72.** For that purpose, the width of the cores of armature **43** and of stator **42** should be approximately equal to the maximum "bounce" of roll **20** considering further the length of the third class lever **49.** Also, link **55** should be adjusted in length by turning the threaded rod **58** so that the excursion of the armature is approximately symmetrical respecting the stator.

While the voltage across field winding **71** may be from **6** to **12** volts in a typical embodiment of the invention, the output current of winding **72** is a fraction of a volt because of the unavoidable large loss of magnetic flux due to the air gap and the low operating frequency. The turns ratio of windings **71** and **72** may be in the order of 1:10 so that considering also that the field current is larger than the output current, the generator **41** as such might be considered a variable alternator.

The rotational speed of shaft **30** is typically between five and 30 revolutions per second and accordingly in a typical embodiment of the invention, the value of inductance **79** should be in the order of 25 Henrys and have a current capacity in the order of 300 ma. While both the distance and speed of armature motion determine the amount of current generated, the effect of inductance **79** at meter **77** provides the operator of roller **10** with a direct, visual indication of the "bounce" of roll **20** and the compaction effectiveness at the particular speed, relative to that of another speed. This allows the operator to quickly "find" or preestablish the optimum speed of shaft **30** at any time. Similarly, any significant lower indication of meter **77** provides the operator with notice of a change in conditions wich suggest a needed change of shaft speed.

We claim:

1. In combination with a compaction machine having a frame of substantial mass, a ground engaging compaction element, resilient means interconnecting the frame and element, said element having manually controllable power-operated means effecting its vertical vibration at any selected frequency within a given range; current indicator means observable by the machine operator, an electric generator having an output winding, a stator fixed to and carried by said frame and an armature having a link connecting the same and said compaction element, said link being vertical such that the armature is oscillated by and in direct relation to the vertical movement of the compaction element relative to the frame, means for mounting and positively guiding the link so that movement of the armature carried by the link maintains a uniform air gap relative to the stator, and an inductive reactance connecting in series the output winding of said generator and said current indicator means whereby the current indicator means is operative to indicate relative changes in the amplitude of vertical movement of the element generally independently of the frequency of oscillation of the armature within said frequency range and whereby the machine operator by variously changing the vibration frequency of the element may readily "find" the frequency of ground resonance as indicated by a pronounced increase in current generation.

2. The combination of claim **1** wherein the current indicating means comprises a D'Arsonval meter with an indicator needle.

3. The combination of claim **1** wherein the compaction element is a roller and the power operated means effecting its vibration is a rotatable shaft concentric with the roller and having an eccentric weight.

4. The combination of claim **1** which further includes a source of direct current and wherein the stator includes a field winding connected to said source of direct current.

5. The combination of claim 4 wherein the generator includes a laminated core of two parts separated by an air gap in the order of 0.006 to 0.010 inch, the stator and the two windings comprising one part and the armature comprising the other part.

6. The combination of claim 4 wherein the turns ratio of the field and output windings are in the order of 1:10.

7. The combination of claim 1 which the means for mounting and positively guiding the link includes a lever which is pivotally connected to the machine frame and to which the armature is fixed and the link is connected.

8. The combination of claim 7 wherein the armature oscillates along an arc and the effective length of the link is adjustable so that the excursion of the armature respecting the stator may be adjusted to be approximately equal in both directions.

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