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Konig et al.

[11] **3,775,019**

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[54] **DYNAMIC SOIL COMPACTING MACHINE**

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[52] **U.S. Cl.** **404/133**

[51] **Int. Cl.** **E01c 19/40**

[58] **Field of Search** .... 94/48, 50 V; 404/133

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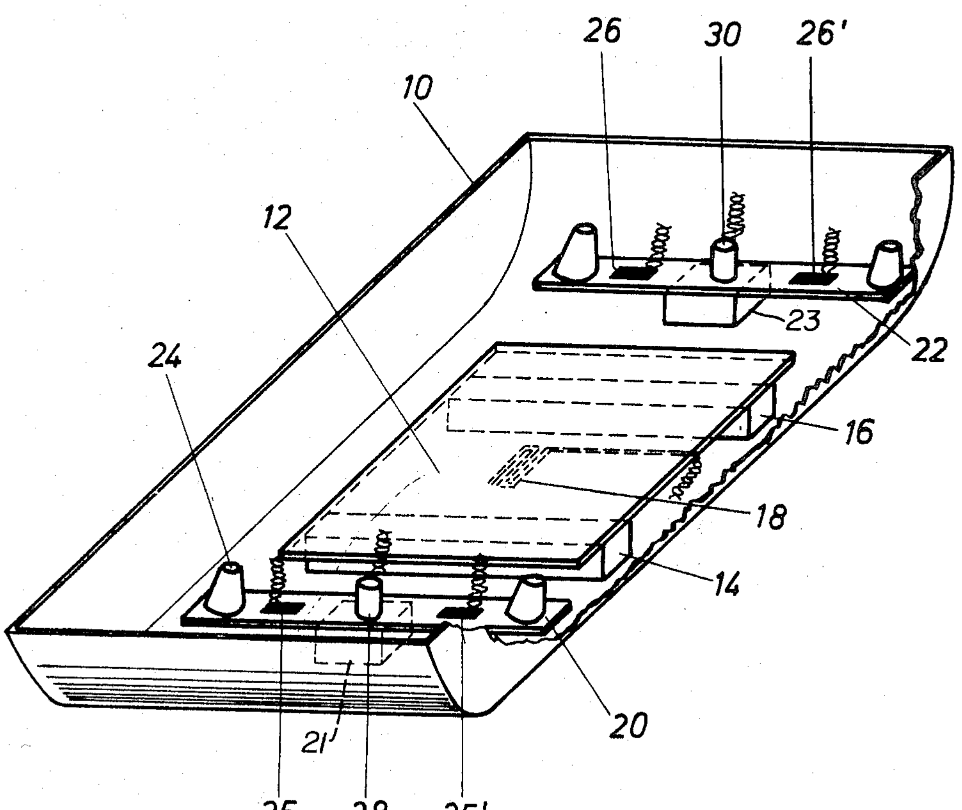
[57] **ABSTRACT**

A first strain gauge fixed to a vibration generator supporting plate, second strain gauges mounted on cross members of a vibrator plate and two accelerometers with vertical recording orientation in a dynamic soil compacting machine provide signals, components of which are added to represent the impact force between the vibrator plate and the soil. Peak values of said added signals are stored in a register. By differentiating the increase in register content a set of pulses from a differentiating element is formed. Either a preset register content or a preset number of pulses is used to trigger the advance motion of the machine and to cancel the register. In a special embodiment the seismic mass of an accelerometer is arranged to form the yoke of an electromagnet the flux of which is adjustable within two limiting values, the first preventing insignificant acceleration from being stored and the second representing the threshold value for triggering.

22 Claims, 4 Drawing Figures



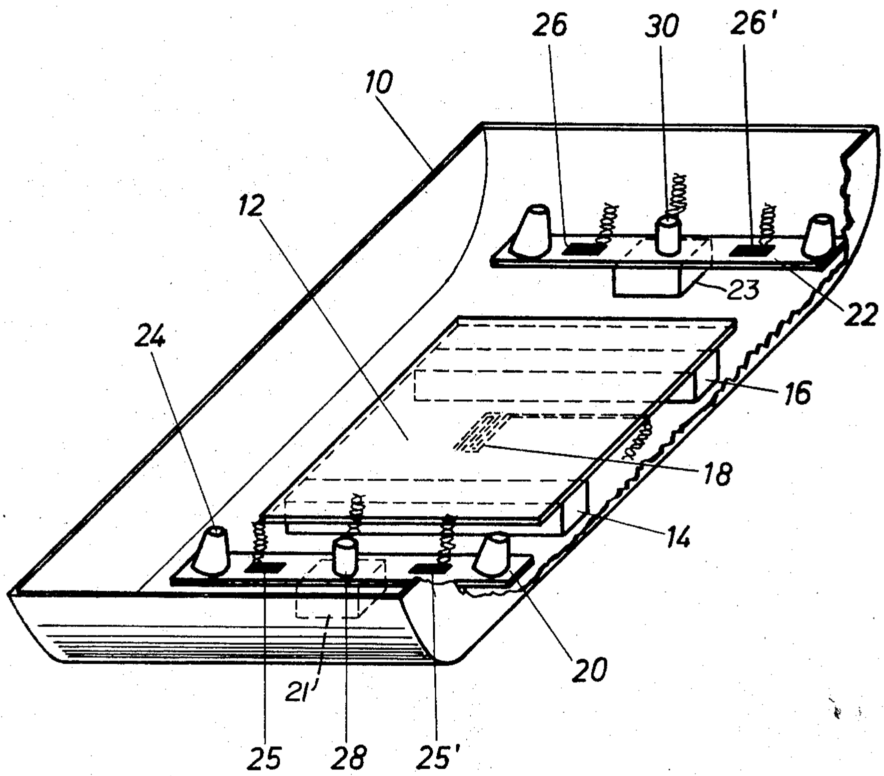


Fig. 1

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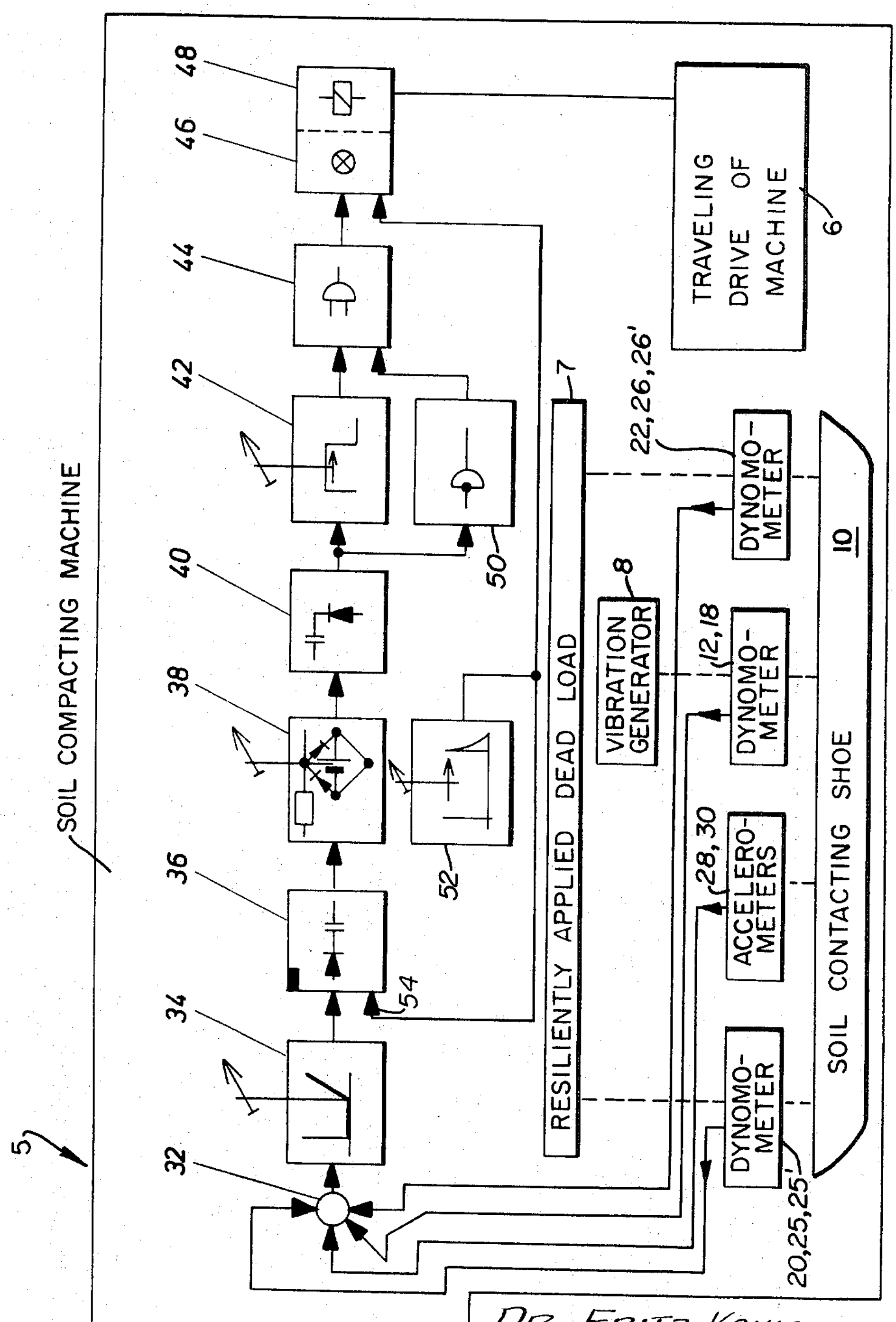
Fig.2



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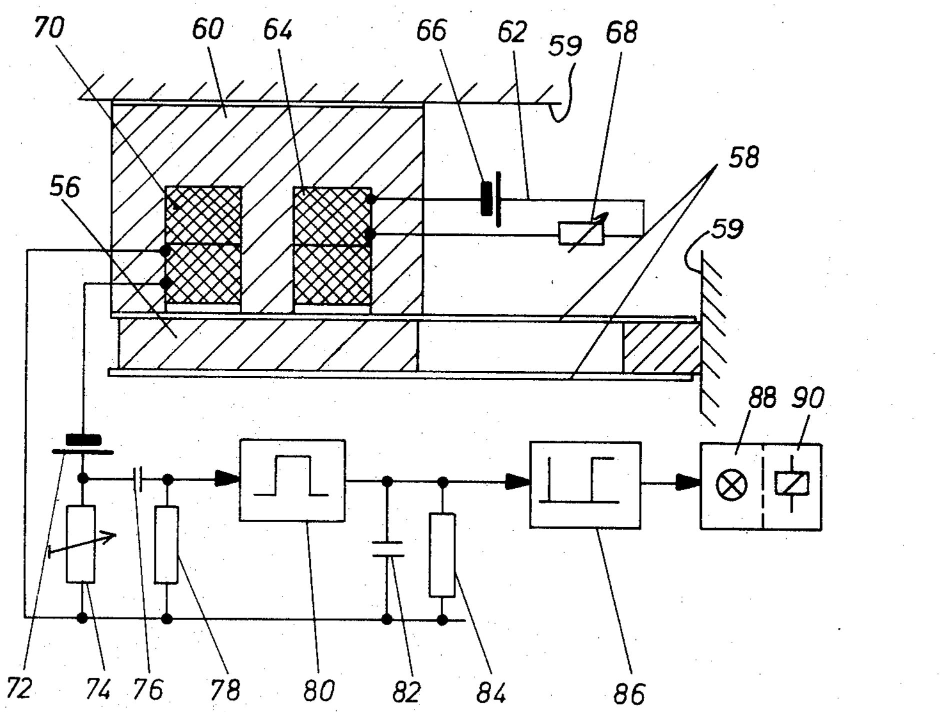

Fig. 3

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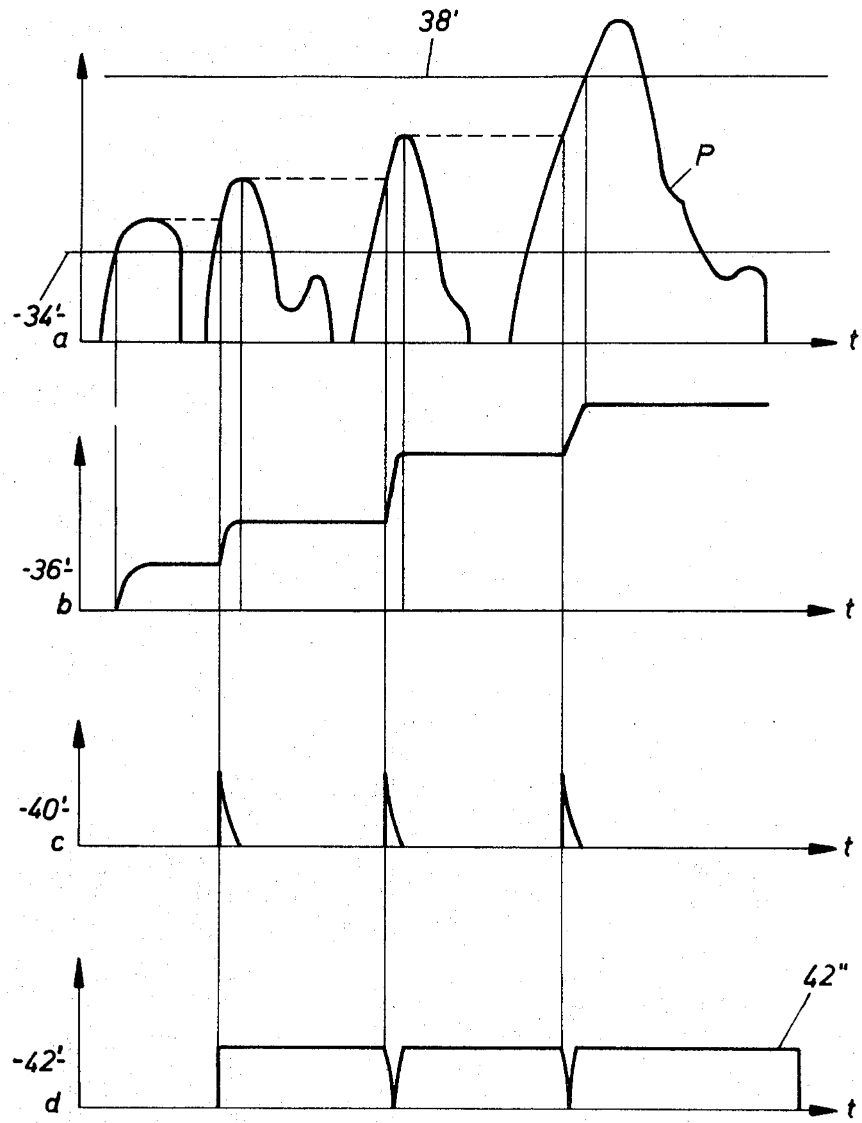

Fig. 4

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DYNAMIC SOIL COMPACTING MACHINE

BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates to apparatus for producing a regulating signal for the travelling drive of a dynamic soil compacting machine.

Dynamic soil compacting machines such as vibrating plates or vibratory rollers exhibit compacting effects which are substantially higher than those of apparatus with a static method of operation but having the same weight. When using such dynamic machines it is, on the one hand, necessary to achieve the required degree of compaction of the material while on the other hand the number of passes required to achieve this end should be kept to a minimum. As a rule, additional passes provide only slight improvements of compaction or those for which there is only slight evidence but they usually involve the same operating expense as the first operating passes which are particularly effective in achieving compaction. In some cases, such additional passes in fact result in a loosening of the material and in an undesirable destruction of the structure.

The optimum operating conditions for a particular compacting operation cannot be obtained from the technical data relating to the available apparatus. It is therefore necessary for a plurality of compacting tests to be performed in order to obtain data regarding the degree of compaction which can be achieved and the number of passes required to this end. This, however, involves the following disadvantages:

a. The test refers to a defined and usually closely limited part of the compacting run. No inspection or observation ensures the correctness of the assumption that the conditions thus found are also optimum for the remaining areas to be compacted.

b. In addition to an adequate soil compaction, uniformity of soil compaction is particularly desirable for reasons of below-grade technology. Only in the smallest number of cases will the conditions of fill dumping and prestressing, for example due to building site traffic, be so uniform that a preplanned compaction would lead to the desired result without suitable additional compaction operations being performed.

c. The uniformity with which a minimum value is reached is of decisive importance for the suitability for acceptance of compacting work since local compacting peaks cannot be compensated by positions with lesser compaction.

d. Many cases call not only for defined minimum values of the dry bulk weight but also for the results of a load plate test as a measure for indicating the load-bearing capacity of a compacted substrate. The relationship between these two parameters is to a large extent exclusively typical of the sample so that adjustment is possible only relative to one of these parameters in the test compaction at the beginning of the operation.

The object of the invention is to detect by measuring means the progressive compaction of the soil at the location at which the compaction is then taking place so that the said compaction can be controlled relative to a value which accords with experience and practical requirements.

According to the invention this problem is solved by sensing means for the force which acts on the working

part of the soil compacting machine and apparatus for producing a regulating signal for the travelling motion of the soil compacting machine relative to the peak values of such force accompanying the impact on to the soil, when either a peak value is not exceeded within a given time by successive peak values or if a peak exceeds the predefined threshold value.

The invention is based on the knowledge that the vibration amplitude which is effective in producing compaction, is the peak force acting on the soil. The forces applied by the working part of the soil compacting machine on the soil have a substantially irregular characteristic. The motion of the working part, for example of a vibrator plate, is defined by different incoherent effects: under the effect of gravitational force and any possible forces due to superimposed loads, the working part describes substantially a ballistic trajectory. There are also the effects of harmonic excitation forces derived from the vibration generator and which may be differently orientated relative to the material at the moment at which the working parts strike such soil. At this moment of time they may be downwardly orientated, thus increasing the impact effect of the striking working part but they may also be upwardly orientated and may thus decelerate the impact of the working part. The soil load bearing density achieved depends to a large extent on the peak force applied. The said peak force defines a certain structure of the individual particles of the soil where such particles are wedged into each other and the application of further forces of lower amplitude results in practically no further alteration of the structure thus obtained. Instead, forces are required which exceed the preceding peak value. On the other hand, increasing load-bearing density causes the soil to become "harder" and correspondingly higher peak values of the impact force or acceleration will occur. According to the invention, the peak value of the impact force is used as a measure for the soil load-bearing density obtained by compaction and if this peak value exceeds a certain threshold, determined from trial runs as corresponding to a desired load-bearing density, a regulating signal will be triggered for the advance motion of the soil compacting machine. This regulating signal may be a visual indication (lamp) which indicates to the operator that he may now advance the soil compacting machine. This regulating signal may however also directly control the travelling drive of the soil compactor.

There are however limits to the compactness of the soil or to put it another way, a soil compacting machine cannot provide soil compaction beyond a defined amount. This is indicated by the fact that a previously recorded peak value of the impact force is not exceeded for a certain period of time. According to the invention, this criterion may also be employed for triggering a regulating signal to cause travelling motion of the soil compacting machine.

A dynamometer for measuring the excitation forces transmitted to the working part and an accelerometer responding to the acceleration (i.e. positive or negative) of the working parts may be provided to measure the impact forces which become effective between the working part of the soil, the signals obtained from the said dynamometer and accelerometer being superimposed (i.e. added in whole or in part) in order to form a signal related to the impact force between the working part and the soil. In a further embodiment of the invention it is possible for the signal of an additional dynamometer to be fed into the system, the second dynamometer responding to the forces which become effective between the working part and the resiliently imposed dead load of the apparatus.

The impact force, the inertia force of the working part and the forces applied by the remaining parts of the soil compacting machine on to the working part, form an equilibrium system in which each component can be defined by reference to the two other omponents. The working part is subject on the one hand to the excitation force exerted by the vibration generator. A further force acting on the working part may for example be exerted by a superimposed dead load, resiliently supported on the working part. The inertia force of the working part is supplied by the accelerometer if the mass of said working part is known. A signal, corresponding to the impact force between the working part and the soil may thus be derived by suitable superimposition of the aforementioned signals.

Apparatus according to the invention are characterized by a peak value register which is based by the signal of the aforementioned sensing element, a differentiating member for differentiating the register contents and a time element which can be re-engaged on each occasion by the output pulses of the differentiating element and, after a defined time, supplies an output signal as regulating signal for the indicating measn or as a regulating signal for a final control member which controls the travelling motion of the soil compacting machine.

The peak value register in each case stores the last maximum value of the impact forces which occur between the working part and the soil. The register content therefore represents a step response function of the, time, steps continuing to occur for as long as fresh peak values occur which exceed the preceding peak value. The steps are differentiated by a differentiating element to produce pulses. Each of said pulses starts a timing element afresh. The timing element supplies a regulating signal when a given period of time has elapsed since the last pulse was received without any additional pulses being received during that time. This means, that if a further pulse is transmitted to the timing element within said predefined time after a pulse starts it, the timing element will begin fresh operation for the defined time. However, if no further pulses are received it means that the last peak value is not exceeded and the machine is evidently unable to effect further compaction beyond the degree already achieved. The defined time of the timing element corresponds to the period of time during which a new peak value would normally have occurred.

To this end, a suitable embodiment of the invention provides for the storage of the peak values to be built up anew in sections. A timer is provided which cancels the register and/or the indicating or control function by means of a time marker sequence. In this method of operation the soil compacting machine is controlled for maximum power. Adaptation to any required power may be obtained by limiting the register content to an adjustable maximum. Reaching or exceeding said adjustable maximum will then result in no further change of the register content, thus "simulating" a state in which a peak value, once reached, cannot be exceeded.

The invention furthermore utilizes the knowledge that an effective compacting operation of the machine is associated with its springing characteristics which give rise to impact forces which exceed the installed excitation forces (unbalanced forces or centrifugal forces). Impact forces below a defined multiple of the machine weight are therefore of no significance for the control of the machine. Accordingly, the invention proposes to suppress not only all upwardly orientated impact forces but also the downwardly orientated impact forces which remain below such a multiple of the dead weight, the suppression taking place at the detection stage. A preferred embodiment of the invention is therefore characterized by means for suppressing the sensing element signals within defined, preferably adjustable threshold values.

This feature also makes it possible for the impact force signal to be supplied exclusively by an acceleration sensing element which responds only to one-sided vertical accelerations.

In this way, the invention advantageously utilizes the facility for limiting the apparatus according to the invention exclusively to the detection of inertia forces of the working part. The acceleration sensing element may have a mass, guided in the sensing direction by radius rods. When in the inoperative state the mass bears on a one-sided stop abutment. To this end it is possible for the mass to bear on the stop abutment under the effect of an adjustable reaction spring, the prestress of the reaction spring representing a threshold value for the measured acceleration. The system may however also be so arranged that the mass comprises an interferrite and the stop abutment is formed by a magnet. The magnet is advantageously constructed as an electro-magnet with adjustable flux. The flux of the magnet may be adjusted by first adjusting means to a first value and second adjusting means for increasing the flux may be provided in accordance with the appropriate masoil on which the work is performed. In an embodiment of this kind it is possible, for example, for two excitation windings to be provided, the first of which, fixed relative to the apparatus — suppresses test signals for inertia forces less than the trajectory or centrifugal forces and whose second — adjustable — results in additional suppression in accordance with the compaction requirements.

In a particularly advantageous embodiment of the invention an accelerometer may be constructed as a test sensing device in such a way that a pulse signal, delivered at the moment at which the seismic mass is forced away from the stop abutment, functions as the output of the accelerometer.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a soil contacting shoe and shows the arrangement of dynamometer and accelerometer.

FIG. 2 is a diagrammatic representation of the overall machine including an associated electric signal flow diagram.

FIG. 3 shows an electro-magnetic test sensing element in accordance with a preferred embodiment of the invention.

FIGS. 4*a* to 4*d* show the signal characteristics relating to the system illustrated in FIG. 2.

DESCRIPTION OF SPECIFIC EMBODIMENTS

The following disclosure is offered for public dissemination in return for the grant of a patent. Although it is detailed to ensure adequacy and aid understanding, this is not intended to prejudice that purpose of a patent which is to cover each new inventive concept therein no matter how others may later disguise it by variations or further improvements. The claims at the end hereof are intended as the chief aid towards this purpose, as it is these that meet the requirement of pointing out the parts, improvements or combinations in which the inventive concepts are found.

In the illustrated embodiment there is a soil compacting machine, generally **5**. It has a travelling drive **6** (e.g., including a throttle control gasoline engine). In some embodiments, as illustrated by U. S. Pat. No. 3,505,885, the travelling drive is obtained by an adjustment of the unbalance of the vibration generator. The soil working part is a shoe **10**. Two soil compacting forces are applied to this shoe, namely, a resiliently applied dead load **7** (from the frame of the machine) and a vibrating action supplied by the vibrator generator **8**.

FIG. **1** is a perspective view showing the working part of the soil compacting machine, namely the, the vibration generator and the upper part of the machine having been omitted. The vibration generator, a centrifugal vibrator, is mounted on a plate **12** which bears on cross members **14** and **16**. A strain gauge **18** is adhesively fixed on to the plate **12**. The force exerted by the vibration generator the soil working part (i. e. shoe **10**) causes flexure of the plate **12** which results in a corresponding signal across the strain gauge **18**. This forms a force measuring dynamometer. The ends of the shoe **10** are provided with cross members **20, 22**, positioned on central supports **21, 23**. The ends of said cross members have tapered trunnions and abutments for the helical springs (not shown) on which the dead weight **7** is supported. The cross members **20** and **22** are stressed in bending by the forces acting between the load on the trunnions **24** and the supports **21, 23**. The cross members are provided with strain gauges **25, 25'** and **26, 26'**, disposed symmetrically relative to the longitudinal median plane of the machine. Thus members **20, 22** along with the strain gauges act as force sensing elements (dynamometers) for the forces which act between the load **7** and the soil working part, i. e. shoe **10**. Two accelerometers **28, 30** with a vertical sensing orientation are mounted on the top of the support of the members **20, 22**. The symmetrical arrangement of the strain gauges **25, 25'** or **26, 16'** and addition of the resulting signals as well as the symmetrical arrangement of the accelerometers **28** and **30** and addition of the signals thereof eliminate the components resulting from rotating motions about horizontal axes which are perpendicular to the working direction.

Upon impact of the shoe **10** with the soil there is the action force of the soil on the shoe and the reaction force of the shoe on the soil. These are necessarily equal, but of opposite sign. When the soil is soft they are comparatively low as compared to the situation when the soil is hard. The reaction force is made up of three components, namely: (1) the force corresponding to the weight of the shoe times its acceleration which upon impact is a negative acceleration (i.e. deceleration); (2) the force exerted on the shoe by the vibration generator **8**; and (3) the dead weight force **7** exerted from the machine through springs. Since the weight of the shoe is a known constant, force No. 1 is a function of the signal produced by accelerometers **28, 30**. Force No. 2 is represented by the signal produced by dynamometer **12, 18**. Force No. 3 is represented by the signals produced by dynamometers **20, 25, 25'** and **22, 26, 26'**. These signals are superposed at the addition means **32** to thereby give a reading of the reaction force.

In the signal flow diagram in FIG. **2**, the signals of the sensor means, i.e., the accelerometers and dynamometers are superimposed at the input side addition means **32**. Here components of the output signals of the accelerometers and dynamometers are added, the components being such that the sum corresponds to the impact force between the shoe **10** and the soil so that in particular during the lifting phase when the vibrator plate is lifted off the soil, a zero sum signal will appear. In the succeeding chain, the suppresing element **34** suppresses the signal components corresponding to impact forces with a magnitude less than that of the vibration excitation force (centrifugal force). The successive peak values of the signals are stored in the succeeding peak value register **36** and are compared in the comparison means **38** with a maximum level (which maximum can be adjusted) in such a way that above the said maximum level only one uniform value is transmitted to the following differentiating element **40**. The pulses of the differentiating element trigger a fixedly adjusted timing element **42** which, after a time interval has elapsed, produces a signal, via a gate circuit **44**, to a responsive means. This responsive means can be a lamp **46**, control relay **48** for the travelling drive, or both. Through a reversal stage **50**, the output signal of the differentiating element **40** acts on the gate circuit **44** in order to prevent conductivity of the signal from the timing element **42** in the event that the timing element is restarted prior to its having run down. A timer **52** acts on the cancelling input **54** of the register element **36** and at the same time ensures cancelling of the indication or of the control function represented by the relay **48**. The control function applied to the travelling drive **6** comprises an acceleration of the forward motion of the soil compacting machine, for example by increasing the travelling drive. It also could be a suitable displacement of the principal operating direction of the vibration generator **8**.

The method of operation of the circuit described hereinbefore is explained hereinbelow by reference to FIGS. **4***a* to *b*.

FIG. **4***a* is a graph with respect to time of the input signals to suppression element **34** which signals represent the forces acting between the working part (e. g. shoe **10**) and the soil. The said force, and thus the graphed signals, is zero in sections when the vibrator plate is lifted off the soil. Maxima of greater or lesser magnitude occur in between. The signals below the line **34'** are suppressed by the action of the suppressing element **34**. The appropriate peak values, that is to say the absolute maxima between two successive zero positions are stored in the register element **36**. In this case, the register content follows the curve **36'** of FIG. **4***b*. The register content is differentiated by a differentiating element **40** so that each step upwardly in the graph of FIG. **4***b* supplies a pulse as indicated in FIG. **4***c* by the curve **40'**. The said pulses start the timing element **42** the output signal **42'** of which is illustrated in FIG. **4***d*. The rear flank **42''** of the output signal triggers the regulating signal for the advance motion of the soil compacting machine. Since, as indicated by curves **42'**, the output signal **42'** is briefly dropped to zero by a pulse

40′ with each renewed start of the timing element **42**, so that there is also a rear flank of the signal, the invention provides for the anti-coincidence circuit with reversal stage **50** and gate circuit **44** which prevents the regulating signal being triggered by such rear flanks. The flank signal will not pass through the gate **44** if a pulse **40′** of the differentiating element appears at the same time.

If the threshold value **38′**, defined by the element **38** (FIG. **2**) is exceeded, this will result in no further increase of the register content. This is shown by pulse P in FIGS. **4***a* and *b*. Accordingly no further pulses **40′** will occur so that the regulating signal is triggered at **42″**.

The embodiment illustrated in FIG. **3** is characterised by a particular simplicity. The soil sensing element is an accelerometer having a seismic mass **56** which forms the yoke of an electro-magnet **60.** Mass **56** is supported by two leaf springs **58** fixed to the frame **59** at their right end. The movement of the leaf springs in supporting the mass is that of a pair of radius rods. On the electro-magnet **60** is a first excitation winding **64** connected by an excitation circuit **62** with a voltage source **66** and an adjustable resistor **68.** This first excitation circuit **62** is adjusted to a fixed setting which provides suppression of low acceleration values. There is a second excitation circuit comprising an excitation winding **70,** a voltage source **72** and an adjustable resistor **74.** The second excitation circuit can be optionally increased only to the power limit of the apparatus relative to the soil on which it acts. When the adjustable limit value is exceeded, the yoke is released and the instantaneous change of flux induces a pulse which is tapped off from the adjustable resistor **74** and is supplied to a pulse former **80** via a capacitor **76** which forms a differentiating element together with the resistor **78.** The pulse from the pulse former **80** charges a RC element having a capacitor **82** and a resistor **84** connected in parallel. Charging of the RC element **82, 84** involves storage which is limited with respect to time during which the indicating means **88** or control means **90** respond via a trigger stage **86.**

We claim:

1. Apparatus for producing a regulating signal for the travelling drive of a dynamic soil compacting machine including, in addition to said travelling drive, a working assembly which imparts impacts to the soil accompanied by forces whose magnitude is affected by the action and reaction of said working assembly and the soil, said assembly having a part in contact with the soil and a vibration generator operatively connected to said part, said apparatus including:

sensor means connected to said working part assembly for measuring said forces and producing output signals representative of the magnitude of the forces;

circuit means connected to said sensor means for storing successive peak values of said output signals, for periodically clearing said stored values, and for comparing incoming output signals with the stored values to produce control signals when a stored peak value is not exceeded within a given time by successive peak values of output signals and also when the peak value of an output signal exceeds a predefined threshold value; and

responsive means connected to said circuit means for producing a response indicative of the control signals to signify whether the compacting machine has satisfied the preselected parameters for action on said soil.

2. An apparatus as set forth in claim **1,** wherein said responsive means comprises a signaling device emitting a sensory perceptible signal to advise an operator to adjust the travelling drive.

3. An apparatus as set forth in claim **1,** wherein said responsive means is connected to said travelling drive to automatically adjust said travelling drive.

4. Apparatus for producing a regulating signal for the travelling drive of a dynamic soil compacting machine including, in addition to said travelling drive, a working assembly which imparts impacts to the soil accompanied by forces whose magnitude is affected by the action and reaction of said working assembly and the soil, said assembly having a part in contact with the soil and a vibration generator operatively connected to said part, said apparatus including:

sensor means connected to said working part assembly for measuring said forces and producing output signals representative of the magnitude of the forces;

circuit means connected to said sensor means for storing successive peak values of said output signals, for periodically clearing said stored values, and for comparing incoming output signals with the stored values to produce control signals when a stored peak value is not exceeded within a given time by successive peak values of output signals and also when the peak value of an output signal exceeds a predefined threshold value;

responsive means connected to said circuit means for producing a response indicative of the control signals to signify whether the compacting machine has satisfied the preselected parameters for action on said soil;

said sensor means including a dynamometer between the vibration generator and said part to measure the excitation forces transmitted by said vibration generator to said part, and an accelerometer positioned on said assembly to measure the deceleration of said part as its movement is resisted by the soil; and

including adding means between said sensor means and said circuit means to superimpose the signals of the accelerometer and the dynamometer to form said output signals.

5. An apparatus as set forth in claim **4,** wherein said assembly includes means for resiliently imposing a dead load on said part, and said sensor means includes a second dynamometer mounted between said dead load and said part for measuring the faces of the dead load on said part.

6. Apparatus for producing a regulating signal for the travelling drive of a dynamic soil compacting machine including, in addition to said travelling drive, a working assembly which imparts impacts to the soil accompanied by forces whose magnitude is affected by the action and reaction of said working assembly and the soil, said assembly having a part in contact with the soil and a vibration generator operatively connected to said part, said apparatus including:

sensor means connected to said working part assembly for measuring said forces and producing output signals representative of the magnitude of the forces;

circuit means connected to said sensor means for storing successive peak values of said output signals, for periodically clearing said stored values, and for comparing incoming output signals with the stored values to produce control signals when a stored peak value is not exceeded within a given time by successive peak values of output signals and also when the peak value of an output signal exceeds a predefined threshold value;

responsive means connected to said circuit means for producing a response indicative of the control signals to signify whether the compacting machine has satisfied the preselected parameters for action on said soil;

said circuit means comprising, in series, peak value register means, differentiating means and a time delay means, said register means storing the peak values of said output signals, said differentiating means differentiating the contents of the register means and sending a differentiated signal to the time delay means, said time delay means providing a signal a fixed period of time after receiving said differentiated signal.

7. An apparatus as set forth in claim **6**, including anticoincidence means connected to said time delay means for suppressing the effect of said signal provided by the time delay means when a differentiated signal occurs simultaneously therewith.

8. An apparatus as set forth in claim **6**, wherein said register means includes means for establishing the maximum peak values that may be stored therein, said last means being adjustable as to said maximum.

9. An apparatus as set forth in claim **6**, wherein said circuit means includes timing means connected to said register means and to said responsive means for clearing the register and cancelling the response.

10. An apparatus as set forth in claim **6**, wherein said circuit means includes timing means connected to said register means for clearing the register means.

11. An apparatus as set forth in claim **6**, wherein said circuit means includes means for suppressing said output signals of an amount less than a given threshold value.

12. An apparatus as set forth in claim **6**, wherein the suppressing means is adjustable so that the threshold value may be changed.

13. In a dynamic soil compacting apparatus wherein a member contacts the soil and applies a force to the soil, the improvement wherein said machine includes:

sensor means on the machine for producing signals which are a function of said force which accompanies the impact on the soil; and

means connected to said sensor means for producing an output signal which is representative of the peak values of said sensor means signals.

14. An apparatus as set forth in claim **13**, wherein said sensor means consists of an accelerometer responsive only to one-sided vertical changes in rate of movement.

15. In a dynamic soil compacting apparatus wherein a member contacts the soil and applies a force to the soil, the improvement wherein said machine includes:

sensor means on the machine for producing signals which are a function of said force which accompanies the impact on the soil, said sensor means including an accelerometer responsive only to one-sided vertical changes in rate of movement, said accelerometer comprises a seismic mass member, a frame, radius rod means connected the member and the frame for restricting the movement of the member of a given path, and stop means preventing movement of the mass in one direction beyond a given position in said path; and

means connected to said sensor means for producing an output signal which is representative of the peak values of said sensor means signals.

16. An apparatus as set forth in claim **15**, including means resiliently urging said member against said stop means.

17. An apparatus as set forth in claim **15**, wherein said accelerometer includes a magnet, said magnet forming said stop means, said member being a magnetic material.

18. An apparatus as set forth in claim **17**, wherein said magnet is an electromagnet, including means connected to said electromagnet for adjusting the magnetic flux thereof.

19. An apparatus as set forth in claim **18**, wherein there are two of said adjusting means, one for setting the flux to a fixed value and the second for varying the flux in accordance with the soil being processed.

20. An apparatus as set forth in claim **19**, wherein said electromagnet has two windings, one of said adjusting means being connected to a first of said windings, the other of said adjusting means being connected to a second of the windings, said circuit means including a resistor connected across one of said windings, a differentiating element connected across said resistor, a pulse former connected to said element and having an output, a capacitor across said output, a resistor in parallel to said capacitor, a trigger connected to said output, said trigger being connected to said responsive means.

21. In an apparatus as set forth in claim **13**, wherein the machine has a vibration generator, the improvement wherein said sensor means includes an accelerometer on said member, and a dynamometer between the member and the generator.

22. Apparatus for producing a regulating signal for the travelling drive of a dynamic soil compacting machine including, in addition to said travelling drive, a working assembly which imparts impacts to the soil accompanied by forces whose magnitude is affected by the action and reaction of said working assembly and the soil, said assembly having a part in contact with the soil and a vibration generator operatively connected to said part, said apparatus including:

sensor means connected to said working part assembly for measuring said forces and producing output signals representative of the magnitude of the forces, said sensor means including a dynamometer between the vibration generator and said part to measure the excitation forces transmitted by said vibration generator to said part, and an accelerometer positioned on said assembly to measure the deceleration of said part as its movement is resisted by the soil;

circuit means connected to said sensor means for storing successive peak values of said output signals, for periodically clearing said stored values, and for comparing incoming output signals with the stored values to produce control signals when a stored peak value is not exceeded within a given time by successive peak values of output signals and also when the peak value of an output signal exceeds a predefined threshold value, said circuit means comprising, in series, peak value register means, differentiating means and a time delay means, said register means storing the peak values of said output signals, said differentiating means differentiating the contents of the register means and sending a differentiated signal to the time delay means, said time delay means providing a signal a

fixed period of time after receiving said differentiated signal; and

responsive means connected to said circuit means for producing a response indicative of the control signals to signify whether the compacting machine has satisfied the preselected parameters for action on said soil.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,775,019 Dated November 27, 1973

Inventor(s) Fritz Konig and Hans-Georg Wascewski

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, lines 47 and 48	delete "for the suitability for acceptance" and insert --as to the acceptability--
Col. 2, line 51	before "soil" second occurrence insert -- particular --.
Col. 3, line 28	"measn" should be --means--
Col. 3, line 36	delete comma (,) before "time"; same line insert "the" before "steps"
Col. 5, line 21	after "namely the" insert --shoe 10-- before the comma (,)
Col. 5, line 27	after "generator" insert --on--
Col. 5, line 33	after "trunnions" insert --24--
Col. 5, line 47	"26,16'" should be "26,26' "
Col. 10, line 2	"connected" should be "connecting"

Signed and sealed this 25th day of June 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents