June 26, 1962 E. P. PEREGRINE ETAL 3,040,591

IMPULSE VIBRATORS

Filed Nov. 5, 1959 3 Sheets-Sheet 1

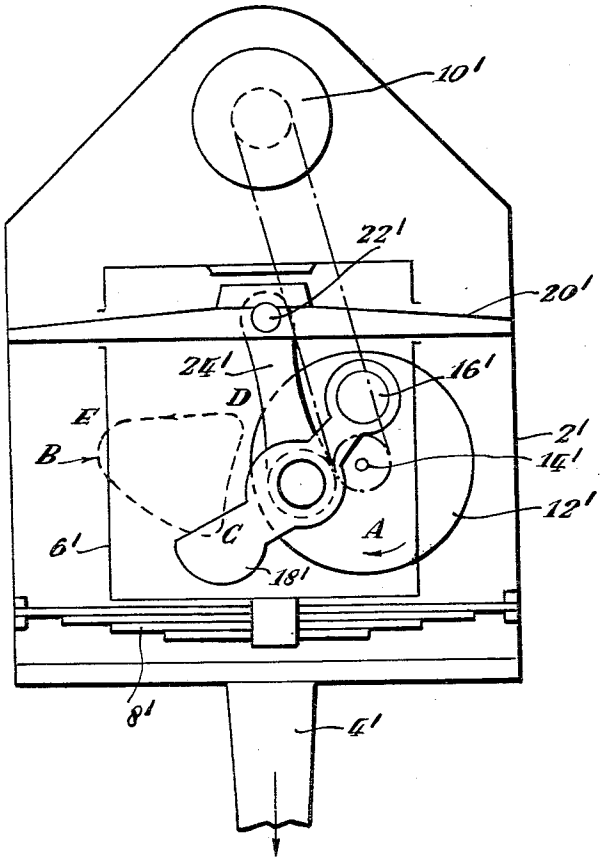


Fig. 1.

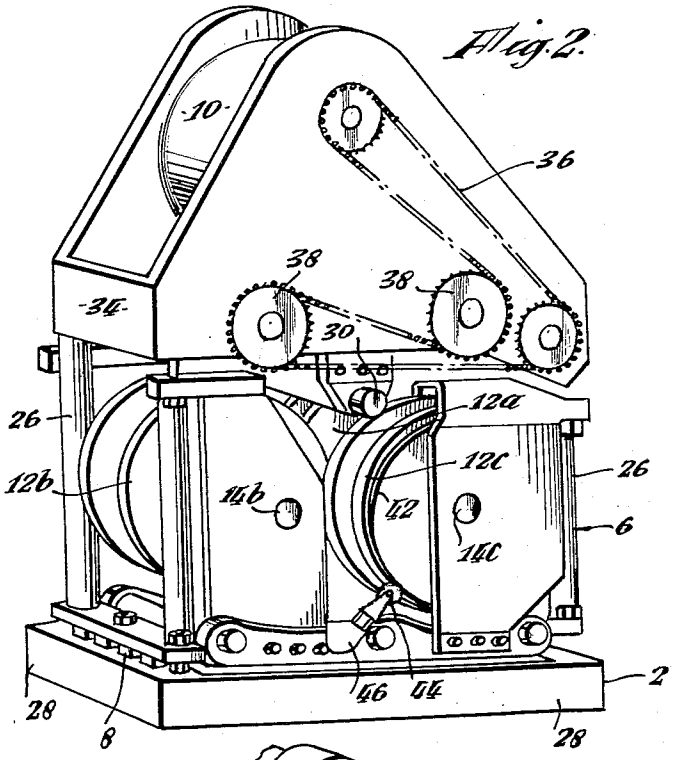
Inventors
Edgar P. Peregrine
Gerald Rogeland
by Albert Jacobs
attorney

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Fig. 2.



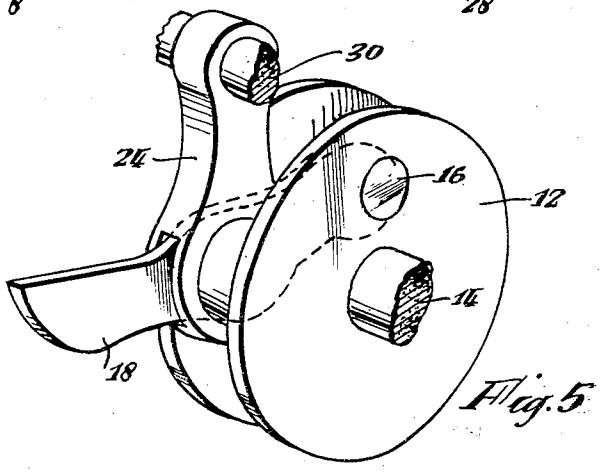


Fig. 5

Inventors
Edgar P. Peregrine
Gerald Rowland
by Albert G. Haeckl
Attorney

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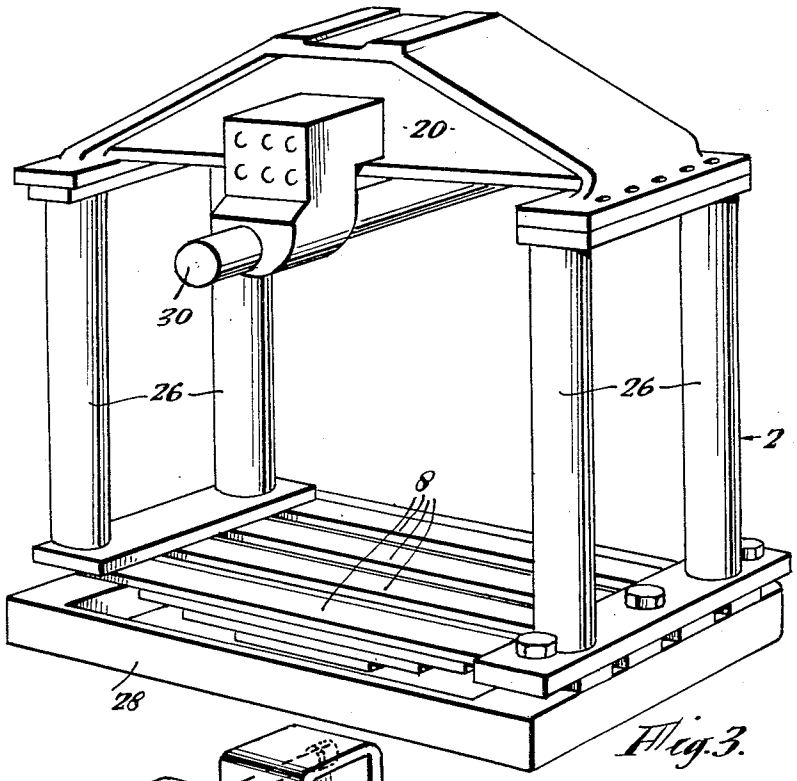


Fig. 3.

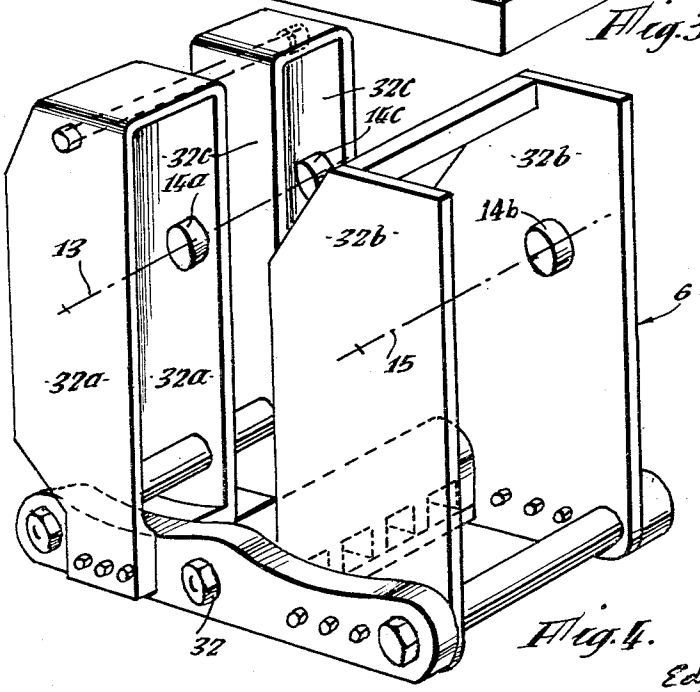


Fig. 4.

Inventors
Edgar P. Peregrine
Gerald Rowland
by Albert Jackson
Attorney

United States Patent Office

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IMPULSE VIBRATORS

Edgar Phillips Peregrine and Gerald Rowland, Royston, England, assignors to The British Steel Piling Company Limited, London, England, a company of Great Britain and Northern Ireland

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10 Claims. (Cl. 74—61)

This invention relates to impulse vibrators and is concerned primarily with the use of such vibrators in pile driving equipment, the object being the reduction in weight and complication of field equipment generally used for this purpose.

According to one aspect of the invention there is provided a mechanical linkage for use in an impulse vibrator, comprising, in combination, a floating link, a rocker link, a rotary crank journalled to one end of the floating link, a lower end of the rocker link being journalled to the floating link intermediate the length of said floating link, a free end of the floating link having a mass, a prime mover being arranged to move said mass through the rotation of said crank so as to generate oscillatory impulses the force which is greater in one radial direction in the plane transverse to the crank than in other directions.

According to another aspect of the invention an impulse vibrator constructed in this manner is provided with a plurality of linkages so that all forces along the operative axis arising from the motions of the linkages are summated and all other forces and couples arising thereby are balanced out.

The invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic illustration of the mechanical linkage and its associated parts,

FIGURE 2 is a perspective view of an embodiment of the invention, with the linkages omitted,

FIGURE 3 is a perspective view of the outer frame of the embodiment in FIGURE 2,

FIGURE 4 is a perspective view of the inner frame of the embodiment in FIGURE 2, and

FIGURE 5 is a scrap perspective view of a linkage used in the embodiment in FIGURE 2.

Referring to the drawings, FIGURE 1 shows an outer frame 2′ attached to the head of a pile 4′, the arrow indicating the operative direction of the pile. An inner frame 6′ is supported on leaf springs 8′ the ends of which are fixed in the outer frame 2′, the inner frame 6′ being thus movable against the springs along the operative axis of the pile 4′. The stiffness of the springs is such that the inner frame 6′ is unable to rock transversely to this axis and if required guides (not shown) may be fitted between the outer frame 2′ and inner frame 6′ to ensure that they are not displaced transversely relative to each other. In addition, stops may be fitted to limit the relative axial motion.

A prime mover 10′ rigidly attached to the inner frame 6′ is connected to drive flywheel 12′ which is suitably mounted on bearings 14′ to the inner frame. A crank pin 16′ on the flywheel 12′ has journalled to it one end of a floating link 18′.

Beam 20′ rigidly attached to the outer frame 2′ carries a shaft 22′ on which the upper end of rocker link 24′ is journalled, its other end being pivotally connected to an intermediate point on the length of floating link 18′. The mass of link 18′ is concentrated in its free end.

Rotation of the flywheel 12′ in the direction of arrow A causes the centre of mass of the free end of the floating link 18′ to follow a path indicated by the broken line B. Over the portion CDE of the path B the motion

is relatively slow but it accelerates quickly to a higher speed over the portion EC, this latter portion occupying some 90° of crank movement. On reaching point E, the mass is constrained to change its path suddenly and its inertia is thereby destroyed, appearing as a tension in rocker link 24′ and thereby transmitted as a driving impulse on the pile 4′. The inner frame 6′ is also impelled to follow this impulse but only to the extent that the flexure of the springs 8′ inflict an accelerative force on the flywheel bearings 14′. The springs thus taking the reaction of the inner frame 6′ with its associated flywheel 12′ and motor 10′, the mass accelerated by the driving impulse is kept at a minimum and the acceleration produced is correspondingly increased.

It will be seen that the mechanism described is an application of the four bar linkage with an eccentric weight located on an extension of the floating or free link so that when the crank link attached to the other end of the floating link is rotated more or less uniformly, as the various inertias permit, the rocker link is made to exert a transient force of high order on what is commonly regarded as the fixed link of the system.

There will be other forces produced in the motion of the linkage that will act along the operative axis, e.g. that from the eccentricity of the flywheel crank, but these are of a lower order than the main impulse and serve only to maintain the pile in a state of motion in the periods between main impulses.

Other stray forces will occur transversely to the operative direction. To counter these further linkages may be added as explained hereinafter so synchronised with the first linkage that forces equal and opposite to those generated by the first linkage are produced in the case of stray transverse forces whereas in the case of forces acting along the operative axis, their resultant is additive.

FIGURES 2, 3, 4 and 5 illustrate an embodiment of the invention in a pile driver. In this arrangement the stray transverse forces and couples are balanced out by using three flywheel-linkage systems. The flywheel axes are parallel and co-planar, the two outer, auxiliary systems being co-axial and located equidistantly from the central main system. Each of the outer systems has half the inertia of the central system. The outer flywheels rotate in the opposite sense to the main flywheel and the systems are so synchronised that their operative impulses occur simultaneously.

The machine comprises an outer frame **2** to the underside of the base of which the pile-driving tool is rigidly attached, and which supports through leaf springs **8** an inner frame **6** carrying flywheels **12***a*, **12***b*, **12***c* driving motor **10** and the connecting drive therebetween. As stated hereinbefore, vertical guides and stops may be fitted between the inner and outer frames.

The outer frame **2** is made up of a base **28** which serves as an oil sump and has attachment means for the tool. Secured above the base are the ends of leaf springs **8** carrying inner frame **6** and vertical pillars **26**. Rigidly connected to the tops of pillars **26** is a beam **20** carrying a bearing shaft or shafts **30** for three rocker links (of which one is shown at **24**) of the linkages.

The inner frame **6** comprises three pairs of rigid webs **32***a*, **32***b*, **32***c* carrying pairs of stub shafts **14***a*, **14***b*, **14***c* on which the flywheels **12***a*, **12***b*, **12***c* are respectively journalled, the flywheels **12***a*, **12***c* being mounted on pairs of stub shafts **14***a*, **14***c* on centre-line **13** and the flywheel **12***b* being mounted on the pair of stub shafts **14***b* on centre line **15**. The webs **32***a*, **32***b*, **32***c* are connected at their lower ends to a rigid structure **32** mounted on the centre of the leaf springs **8**. Extending upwardly and rigidly connected to the webs is a structure **34** housing the induction motor **10**′. Not shown in FIGURE 4 is a rigid structure **34** extending upwardly from the webs

32*a*, 32*b*, 32*c*. This structure may be integral with the webs or it may be rigidly bolted or welded thereto. On both end faces of housing **34** two layshafts **38** are suitably mounted and are rotated in opposite senses by a chain drive **36**. A further chain-belt (not shown) from a second sprocket wheel situated inside housing **34** on each layshaft **38** takes the drive to sprocket wheels (not shown) integral with or rigidly attached to the flywheels **12***a*, **12***b*, **12***c* of the mechanisms, two of the shafts driving the main flywheel **12***b* and one each the auxiliary flywheels **12***a*, **12***c*. Alternatively, the drive to the flywheels may be taken by gearwheels instead of chains and sprockets.

Provision is made for adjustment of the chain drive to allow synchronisation of the three rotating systems. This is achieved by incorporating a friction clutch in the outer sprocket-wheels of each of the four layshafts **38**.

The links **18**, **24** of each mechanism are symmetrically disposed about a central plane to obviate flexural stresses upon them. FIGURE 5, illustrating a linkage shows the arrangement which is common to all three sets of linkages. The flywheel **12** is divided into two webs connected by crank pin **16**, the space between the pair of webs being wide enough to allow the rocker link **24** to move freely between their inner faces.

Two lubricating pumps **46** mounted one on each end of the outer frame **2** are actuated by an eccentric **42** on each of the two outer flywheels **12***a*, **12***c*, the eccentrics contacting spring-loaded roller followers **44** attached to the pump pistons. Each pump delivers lubricating oil from the sump in base **28** to a common manifold (not shown) supplying oil to all the bearings. A non-return valve is fitted in each delivery line from pump to manifold.

When assembled for operation the complete apparatus is provided with covers to maintain the interior dust-free and so improve the life of the bearing surfaces of the moving parts.

Balancing of the stray forces may be achieved by other arrangements than the one described. Two systems of equal inertia may be arranged with their corresponding parts in the same planes, or, two systems each half the inertia of a third system may be arranged equidistantly above and below the third system.

The invention reduces the amount and therefore the cost of work to be done in pile driving and increases the rate at which piles may be driven. Further, orthodox pile driving plant may be dispensed with and a lighter prime mover such as an electric motor or internal combustion engine substituted for the usual steam plant employed.

The scope of the invention is not limited to pile driving. The mechanism is equally applicable to other applications requiring oscillating impulse forces. It can be used, for example, to assist the motion of a plough through the ground, or in the operation of such apparatus as a mechanical hammer. It may also be used for the extraction of piles.

What we claim and desire to secure by Letters Patent is:

1. Impulse vibrator comprising a plurality of mechanical linkages and a rotary prime mover wherein each linkage includes operatively connected within an interconnected inner frame and outer frame, a floating link, a rocker link and a flywheel with a crank member thereon, a first journal at one end of said floating link, a free end of predetermined mass extending from a second journal at an intermediate point along the length of said floating link, said first journal being operatively connected to said crank member, said second journal being operatively connected to the lower end of said rocker link, said flywheel being rotatably connected to said inner frame and the upper end of said rocker link being operatively connected to said outer frame through which the oscillatory impulse is applied, said linkages being so arranged that all forces along the operative axis arising from the motions of the linkages are summated and all other forces and couples arising thereby are balanced out.

2. Impulse vibrator comprising a plurality of mechanical linkages according to claim 1, wherein said inner frame is secured to said outer frame in such manner that it is resiliently movable thereto along the operative axis of the vibrator.

3. Impulse vibrator comprising a plurality of mechanical linkages according to claim 1, wherein in each linkage the crank member and its flywheel, the floating link and the rocker link are symmetrically disposed about a central plane.

4. Impulse vibrator comprising three mechanical linkages according to claim 1, wherein two of the linkages are arranged equidistantly on each side of the third linkage, each having half the inertia of the third linkage and rotating in the opposite sense to the third linkage, all three linkages having co-planar and parallel axes and being capable of synchronisation so that their operative impulses occur simultaneously.

5. Pile driver employing a plurality of mechanical linkages and a rotary prime mover wherein each linkage includes operatively connected within an inter-connected inner frame and outer frame, a floating link, a rocker link and a flywheel with a crank member thereon, a first journal at one end of said floating link, a free end of predetermined mass extending from a second journal at an intermediate point along the length of said floating link, said first journal being operatively connected to said crank member, said second journal being operatively connected to the lower end of said rocker link, said flywheel being rotatably connected to said inner frame and the upper end of said rocker link being operatively connected to said outer frame through which the oscillatory impulse is applied and said inner frame is secured to said outer frame in such manner that it is resiliently movable thereto along the operative axis of the vibrator, said linkages being so arranged that all forces along the operative axis arising from the motions of the linkages are summated and all other forces and couples arising thereby are balanced out.

6. A mechanical linkage for an impulse vibrator comprising, in combination, a supporting frame, a floating link, a rocker link and a rotary crank, said crank being rotatably connected to said frame and journalled to one end of the floating link, a lower end of the rocker link being journalled to the floating link intermediate the length of said floating link and an upper end of the rocker link being journalled to said frame, a free end of the floating link having a mass, a prime mover secured to said frame being arranged to move said mass through the rotation of said crank so as to generate an oscillatory impulse the force of which is greater in an operative direction than in an opposite, return direction.

7. Mechanical linkage operatively connected in an impulse vibrator comprising in combination, a support frame, a flywheel journalled to said frame with a crank thereon, a rocker link having an upper end journalled to said frame and a floating link, said crank being journalled to one end of the floating link, a lower end of the rocker link being journalled to the floating link intermediate the length of said floating link, a free end of the floating link having a mass, a prime mover secured to said frame and being arranged to rotate said flywheel to move said mass so as to generate an oscillatory impulse, the force of which is greater in one direction in the plane transverse to the crank axis than in other directions.

8. Mechanical linkage according to claim 7 wherein the flywheel and said links are operatively connected within an interconnected inner frame and outer frame, said flywheel being rotatively connected to said inner frame and the upper end of said rocker link being operatively connected to said outer frame through which said oscillatory impulse is applied.

9. Mechanical linkage according to claim 7, wherein the flywheel and said links are operatively connected within an interconnected inner frame and outer frame, said flywheel being rotatively connected to said inner frame and the upper end of said rocker link being operatively connected to said outer frame through which said oscillatory impulse is applied, said inner frame being secured to said outer frame in such a manner that it is resiliently movable thereto along the axis of said oscillatory impulse.

10. Mechanical linkage according to claim 7 wherein

the flywheel and its crank, the floating link and the rocker link are symmetrically disposed about a central plane.

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