United States Patent

Hoeffleur

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[54] **SPRING-LOADED HAMMER**

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[51] **Int. Cl.**.....**B25d 11/06,** F16h 33/18

[58] **Field of Search**.....173/49

[56] **References Cited**

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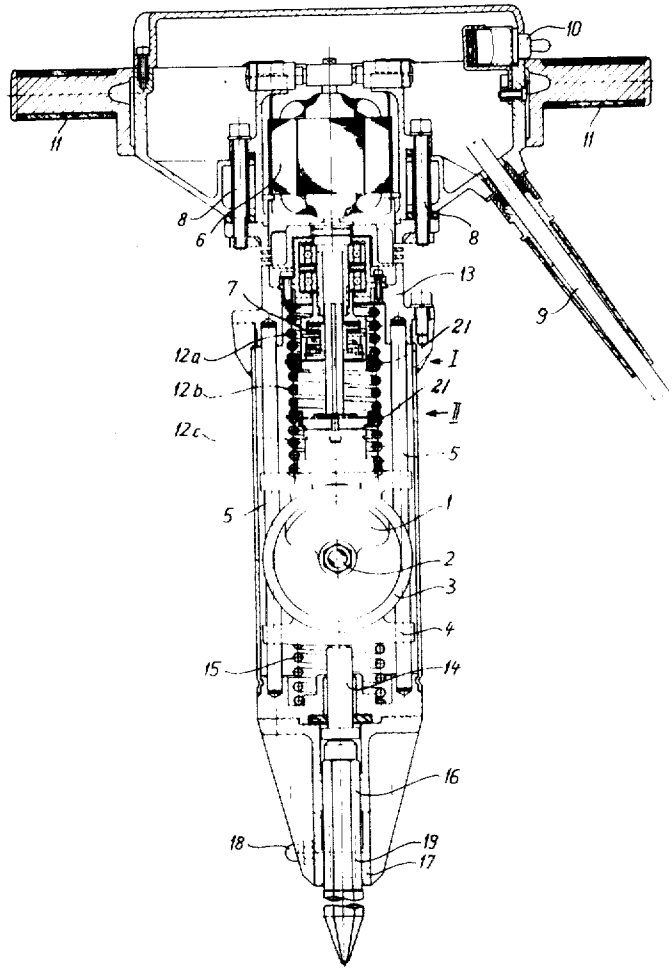
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[57] **ABSTRACT**

A spring-loaded hammer or percussion drill with a mechanical vibratory system having vibratory masses and springs for cushioning the masses and transmission means so that part of the energy of vibration is transferred in impact form to a percussive tool.

5 Claims, 2 Drawing Figures



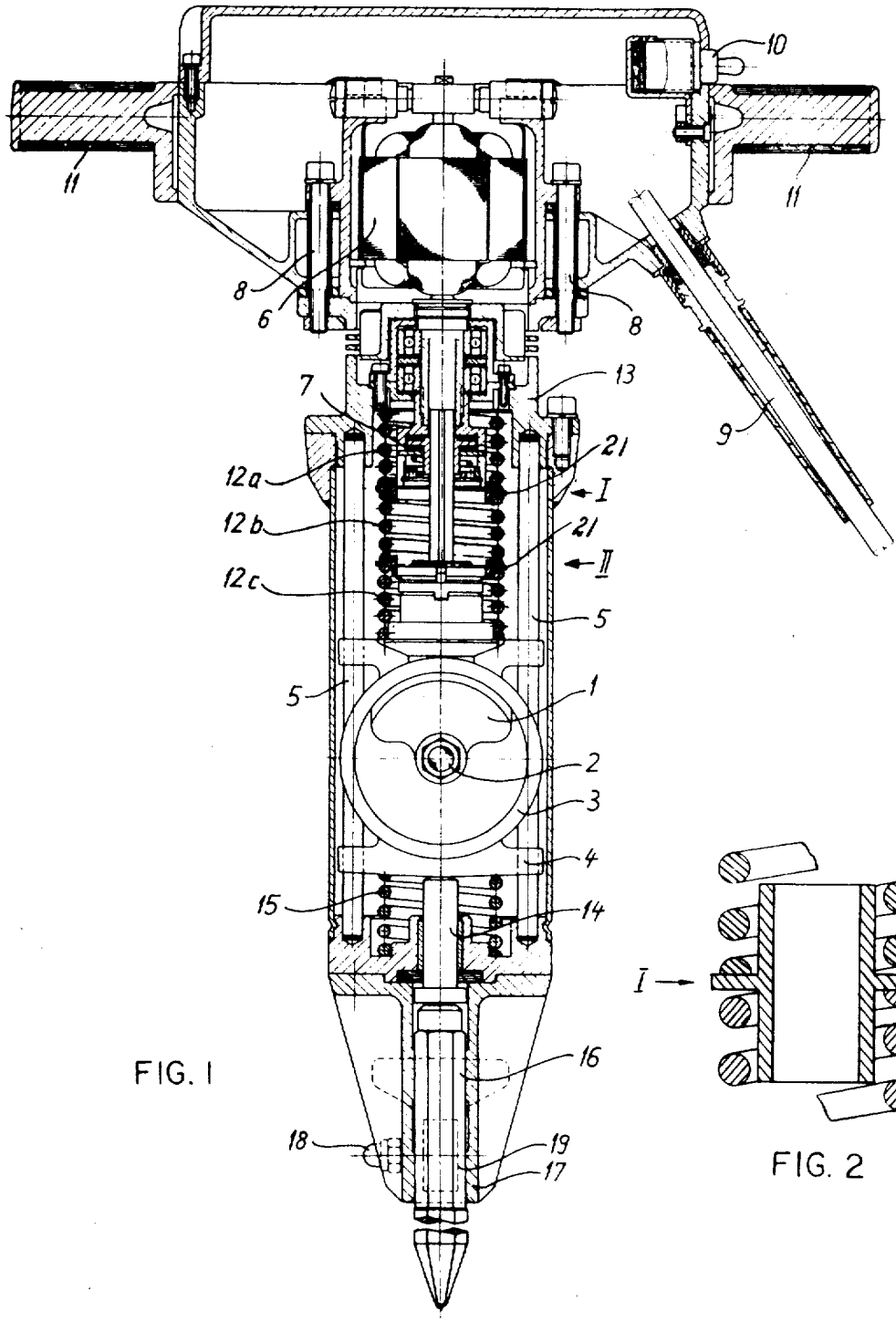


FIG. 1

FIG. 2

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SPRING-LOADED HAMMER

The invention relates to a spring-loaded hammer or percussive drill with a mechanical vibratory system comprising one or more vibratory masses and several component springs for cushioning the vibratory masses against fixed bearing members mounted within the hammer casing, and with means whereby the vibratory masses can be caused to vibrate, as well as means of transmission whereby, at every vibration of those masses, part of the energy of vibration is transferred in impact form to a percussive tool bit in such a way that the lines of application of the spring action produced by the component springs, of the oscillatory displacement of the center of gravity of the vibratory masses, and of the force vector of the impact transmitted to the bit at every vibration, lie in the produced longitudinal center line of the bit, while that side of the vibratory masses which faces away from the said means of transmission bears against at least one main spring, at least one buffer spring being provided on that side of the vibratory masses which faces towards the said means of transmission.

Spring-loaded hammers of that type have long been in existence. In such hammers, as a rule, the means whereby, at every vibration of the masses, part of the energy of vibration is transferred in impact form to the tool bit consists of a transmission pin in axial alignment with the bit, one end of the pin being in contact with the end of the tool bit shank, while the other end of the pin receives the impact of the vibratory masses at every vibration, that is to say whenever the vibratory mass follows the rise of the oscillation half-wave, during which the mass may be regarded as carrying out an excursion from a position of rest towards the transmission pin.

Energy of vibration is withdrawn from the mass by the impact, amounting at its maximum to the whole of the kinetic energy possessed by the mass at the moment when it strikes the transmission pin. The maximum impact energy that can be transferred to the transmission pin varies according to the particular point to which one adjusts the moment of impact of the mass on that pin, in the said rise of the half-wave of the vibrational movement of the mass towards the pin.

Consequently, assuming a particular impact energy to be required, either one can work with a relatively large mass and/or with a very high energy of vibration in the mechanical vibratory system already mentioned, the moment of impact of the mass on the transmission pin being set in the vicinity of the maximum for free vibration of the mass, or one can use a considerably smaller mass and/or a mechanical vibratory system with a far lower energy of vibration, the moment of impact of the mass on the transmission pin being then set more in the lower part of the rise of the free vibration half-wave approaching the transmission pin. In the former case, the maximum impact energy is small compared to the energy of vibration of the mechanical vibratory system, and the interference with free vibration caused by the blows of the mass on the transmission pin is accordingly fairly small. This solution thus offers the considerable advantage of there being little or no interference with the vibration of the mass, but it suffers the great drawback that the mechanical complication and expense of the vibratory system are relatively high, as is also its weight, in addition to which the build-up time of the mechanical vibratory system, and hence the time elapsing from the moment of switch-on of the hammer to that of useful performance, is comparatively long. In the latter case, that is to say when the moment of impact lies in the lower part of the rise already mentioned, the maximum impact energy already constitutes a fairly high proportion of the energy of vibration of the resonant circuit and may even equal the energy of free vibration in the event of the moment of impact being set at the start of the said rise, that is to say at the zero transition point of free vibration. Now, if precisely the same impact energy were transferred from the mechanical vibratory system to the transmission pin at each blow, then, even with the moment of impact in such a position in the said rise, quasi-stationary, that is to say cyclically repeated, vibration would arise in the mechanical vibratory system. This, however, would not be simply sinusoidal, but would be overlaid by harmonics, with a fundamental frequency governed not only by mass and by the spring characteristic of the mechanical vibratory system, but also by the impact energy transferred to the transmission pin at every blow. Since, however, the impact energy transferred to the transmission pin at every blow differs in practice according to the working conditions encountered by the percussive bit at the point where it is being used, there will arise in practice, when the moment of impact lies in the lower part of the said rise, irregular vibration of the mechanical vibratory system, in which a great deal of the power fed by the drive to the mechanical vibratory system will be wasted within the vibratory system itself, so that the power available for transfer to the bit will be reduced accordingly. Furthermore, the sequence of blows will be irregular or their frequency will be subject to wide variation.

It was to remedy this — that is to say to ensure a fairly constant frequency of percussion and a vibration that is repeated to some extent cyclically in the mechanical vibratory system, without having to tolerate the extra technical problems and expense entailed by a substantial increase in the vibrational energy of the mechanical vibratory system and/or a substantial enlargement of mass and the raising of the spring characteristic of the mechanical vibratory system — that the buffer spring mentioned earlier was provided on that side of the vibratory mass which lies towards the transmission pin. The effect of such a buffer spring is substantially that it keeps more or less constant the energy that is transferred, to the transmission pin and buffer spring combined, by the vibrating mass as it strikes the buffer spring and transmission pin. In order words, when the impact energy transferred to the transmission pin is small (When, for example, the object being attacked offers little resistance to the bit), the buffer spring absorbs the "unused impact energy" and returns it to the mechanical vibratory system; and when the impact energy transferred to the transmission pin is great (that is to say when the object being attacked offers great resistance to the bit), the buffer spring is not compressed and therefore absorbs no energy. At the same time, because of the great resistance offered to the bit by the object under attack, a considerable proportion of the impact energy transferred to the transmission pin is reflected at the object under attack and

then likewise fed back once more through the transmission pin to the mechanical vibratory system. The effect produced by the buffer spring is thus approximately the same, both when the object being attacked is soft and when it is hard, namely that, out of the total energy transferred by the vibrating mass to the transmission pin and buffer spring upon impact with them, any part that cannot be transferred to the object under attack is conveyed back again to the mechanical vibratory system. What is also achieved by the buffer spring is that the energy transferred from the vibrating mass to the transmission pin and buffer spring remains substantially constant, irrespective of the consistency of the object under attack, thereby producing the conditions already mentioned, namely constancy of impact energy at every blow and hence also periodicity in the vibration of the mechanical vibratory system.

This vibration, however, as has likewise been mentioned already, is overlaid to a considerable extent by harmonics. It is only, that is to say, a quasi-stationary vibration imposed by the drive, and by no means a pure resonance vibration. The harmonics included in this vibration are naturally also communicated to the main spring that has been mentioned, against which that side of the vibrating mass which faces away from the means of transmission is brought to bear. The result is that the main spring vibrates not only to the fundamental frequency, but also to the harmonics, which in many cases lead to quite considerable energy losses or the loss of considerable proportions of the energy of vibration. These energy losses in turn result in a reduction in the amplitude of vibration, that is to say a shortening of the travel of the vibrating mass. That is probably also the reason why spring-loaded hammers, despite the improved working obtainable by the use of such buffer springs, are seldom used in practice, because the said harmonics in the vibration of the main spring make themselves undesirably noticeable in the form of energy losses and in certain other important respects.

The problem which the invention sets out to solve is therefore to eliminate the difficulties arising from harmonics in the main springs of hammers of the type referred to in the preamble and to provide a spring-loaded hammer in which the reduction in performance due to harmonics in the vibration of the main spring is either non-existent or greatly reduced.

This the invention achieves, in a spring-loaded hammer of the type in question, by virtue of the fact that the characteristics of the main spring at particular points along its length differ from the spring characteristics elsewhere along its length.

In one recommended form of hammer embodying this principle, the main spring is divided. For this purpose, the main spring may be divided into several — preferably two — equal lengths.

When the main spring is divided, it is also of advantage for the characteristics of the main spring or the parts thereof to be the same, or at least approximately the same, as those of the buffer spring. In that case, two or three springs, as desired, identical to the buffer spring, can be used one above the other as the main spring, this having the further advantage, as regards manufacture, that springs of only one kind are needed for such a hammer.

The individual parts of the main spring may be linked together by collars.

Another possible way of providing the main spring with characteristics which differ at individual points along its length is to provide the main spring with non-springy turns, preferably at one or two points by which the spring is divided into equal lengths.

The invention is described hereunder with the aid of the accompanying drawing of an example embodying the principle thereof wherein:

FIG. 1 is a longitudinal section of a spring hammer in accordance with the present invention; and

FIG. 2 is a view of a pair of abutting main spring sections, taken at line I and typical for that also taken at line II, slightly enlarged.

As to details, this hammer has four vibratory masses, mounted eccentrically, in pairs of equal eccentricity, on a common shaft, there being two outer vibratory masses on the ends of a central shaft and two inner vibratory masses on a hollow shaft surrounding the central shaft. The two shafts are driven round in opposite directions, at the same speed, by a common bevel pinion acting on two bevel wheels, the teeth of which face towards each other. The eccentricity of the masses in relation to one another is such that the inertial forces of the eccentrically mounted masses are superimposed on one another in the longitudinal direction of the hammer and cancel one another out in the transverse direction. One of the outer vibratory masses, **1**, the inner shaft **2** and the rear side of one of the bevel wheels, **3**, are shown in the drawing. The inner shaft **2** is mounted in a vibration block, **4**, which is free to move longitudinally, guided by the guide rods **5**. The hollow shaft already referred to is mounted on the inner shaft **2**. The bevel pinion already mentioned, for driving the two bevel wheels, is driven by the electric motor **6** through a safety friction clutch, **7**. As will be observed, the motor **6** is housed in the top of the hammer and secured to the hammer casing by bolts, **8**. Current is supplied to it by the supply lead **9** and switch **10**. The top of the hammer also carries two hand-grips, **11**, for holding the hammer. The vibration block **4**, with the four vibratory masses such as **1**, bears, through the agency of the three-part main spring **12***a*/**12***b*/**12***c*, against part **13** of the hammer casing. The main spring **12***a*/**12***b***12***c*, and the vibratory mass formed by the vibration block **4** plus its four rotating masses and all other parts rigidly connected to the vibration block, represent the two energy-storing elements of the mechanical vibratory system mentioned previously. At every vibration, the vibration block **4** strikes the transmission pin **14** and the buffer spring **15** and transfers partly to the transmission pin **14** and partly to the buffer spring **15** a percussive energy approximately equal to the kinetic energy of the vibration block **4** at the moment of impact. That portion of this percussive energy which is imparted to the transmission pin **14** is passed on to the percussion bit **16** and thence to the object under attack, by which it is either entirely absorbed (in the case of soft or tenacious material, for example) or only partially absorbed and partially reflected (in the case of hard material), in which latter event the reflected energy is transmitted back through the percussion bit **16** and transmission pin **14** to the vibration block **4**. The percussion bit **16** has freedom of longitudinal motion within the holder **17** and has only the end of its shank bearing against the transmission pin **14**. To prevent the bit from falling out of the holder, the latter

contains a sliding pin that can be held fast by a screw, **18**, and the bit is slotted accordingly at **19**. Removal of this securing pin enables the bit to be changed.

In the present example, the main spring **12***a–c* is composed of three springs, each identical to the buffer spring **15**, which are fitted one above the other. Hence, the main spring **12***a–c* has one point, I, where the springs **12***a* and **12***b* are in contact, and another point, II, where the springs **12***b* and **12***c* are in contact, at which its spring characteristics differ from those of the individual springs **12***a*, **12***b* and **12***c*. At those points I and II, only longitudinal compressive forces, i.e. compressive forces in the direction of the longitudinal center line of the springs, are transmitted, but no longitudinal tractive force or, more especially, torque or forces acting transversely to the longitudinal center line.

In FIG. **2**, it can be clearly seen that portions of both springs **12***a* and **12***b* are flattened so as to flatly abut against one another at line I. It should be noted also, that springs **12***b* and **12***c* are similarly flattened so as to flatly abut against one another at line II, as seen in FIG. **1**.

The development of harmonics, which tend to be generated in the main spring by reason of the harmonics overlying the motion of the vibratory mass, is thereby largely prevented. At all events, energy-wasting self-generated resonant responses in the main spring are as good as non-existent or, if they do arise, are in any case greatly reduced. Other forms of deviation in the characteristics of the main spring, such as, for instance, the incorporation of non-springy turns, will serve the same purpose as the use of a divided spring. Non-springy turns, of course, are not altogether comparable to separation points, because the physical action of non-springy turns differs from that of separation points; non-springy turns should be regarded, rather, as interpolated masses capable of transmitting only longitudinal forces.

The particular advantage of using a main spring **12***a–c* made up of several (in the present case, for example, three) part springs similar to the buffer spring **15** is that the spring characteristic of the individual parts of the main spring is then equal to that of the buffer spring, the desirable outcome of this being that the harmonic component of the motion of the vibratory mass is kept small. This in turn means that the magnitudes tending to generate natural vibrations in the spring are small from the outset, which places a further obstacle in the way of the stimulation of resonant responses in the main spring.

Because of the complexity of the subject and owing to considerable difficulties concerned with measurement technique, it has not been possible to determine with any certainty what are the physical effects responsible for the fact that the natural vibrations of the main spring are considerably reduced or almost entirely prevented by the widely varying changes in the spring characteristics at particular points. The foregoing explanations can therefore serve only to demonstrate the problem and no claim can be laid to completeness or to correct interpretation of the observed effects. At all events, a distinct moderation was observed in the type and development of the main spring vibrations when the main springs used had discontinuities in their spring characteristics at particular points. The effect was even more marked when springs identical to those used for the buffer **15** were employed as sections of the main spring.

As to the size of the buffer spring **15**, it remains to add that this must be able, within its compressibility range, that is to say within its maximum travel as a spring, to absorb the entire kinetic energy of the vibratory mass at the moment of impact, as well as the potential energy represented by the force of gravity acting on the vibratory mass. In absorbing this total energy, the buffer spring should not require to carry out more than a part of its maximum travel, rather than the whole or nearly the whole of it. In the present instance, the size of the buffer spring affects more than the action of the buffer spring as such, in that the main spring, too, is composed of springs identical to the buffer spring.

In addition to the example shown in the drawing, with three springs identical to the buffer spring serving as the main spring, a main spring made up of two springs identical to the buffer spring has been tried and found highly satisfactory. Here again, the conditions, as far as they could be observed, were much the same as with the example illustrated.

Finally, it is worth mentioning that when collars, such as **21**, are fitted at the junction between the individual springs **12***a*, **12***b* and **12***b*, **12***c* composing the main spring, in order to exclude the possibility of the individual springs moving sideways in relation to the common longitudinal center line, this has no observable adverse action on the advantageous effect of subdividing the main spring. The distinct moderation in the type and development of the main spring vibrations, already referred to, could still be seen to be unchanged after the fitting of such collars. It should be stated, however, that the collars were very light, consisting substantially of no more than a short section of tubing having a short flange-like peripheral protruberance in the middle, between the tube ends as clearly shown in FIG. **2**.

What I claim is:

1. A spring-loaded hammer or percussive drill with a mechanical vibratory system comprising one or more vibratory masses (**1**) and several component springs including a main spring and a buffer spring (**12***a–c* and **15**) for cushioning the vibratory masses against fixed bearing members (**13**) mounted within the hammer casing, and with means (**6** and **7**) whereby the vibratory masses can be caused to vibrate, as well as means of transmission (**14**) whereby, at every vibration of those masses, part of the energy of vibration is transferred in impact form to a percussive tool bit (**16**) in such a way that the times of application of the spring action produced by the component springs, of the oscillatory displacement of the center of gravity of the vibratory masses, and of the force vector of the impact transmitted to the bit at every vibration, lie in the produced longitudinal center line of the bit, while that side of the vibratory masses which faces away from said means of transmission bears against said main spring (**12***a–c*), said buffer spring (**15**) being provided on that side of the vibratory masses which faces towards the said means of transmission; characterized in that said main spring, at particular points (I and II) along its length,

has different spring characteristics from those which apply elsewhere along its length, said main spring being divided at such particular points.

2. A spring hammer as claimed in claim 1, in which the spring constant of the individual parts (12*a*, 12*b* and 12*c*) of said main spring is substantially the same as that of said buffer spring (15).

3. A spring hammer as claimed in claim 1, in which said divided main spring is linked together by collars.

4. A spring hammer as claimed in claim 1, in which said main spring is divided into at least two equal lengths (12*a*, 12*b* or 12*c*).

5. A spring hammer as claimed in claim 4, in which said at least two springs (12*a*, 12*b* or 12*c*) are identical to said buffer spring (15) and are fitted one about the other, to serve as said main spring (12*a*–*c*).

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,682,254 Dated August 8, 1972

Inventor(s) Albert Hoeffleur

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

In the title page, please insert -- claims priority of

Swiss application No. 10531/69, filed July 10, 1969 --

Signed and sealed this 20th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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