4 Sheets—Sheet 1.

G. I. WASHBURN.

Thermal Motor.

No. 48,607.

Patented July 4, 1865.

Fig. 1.

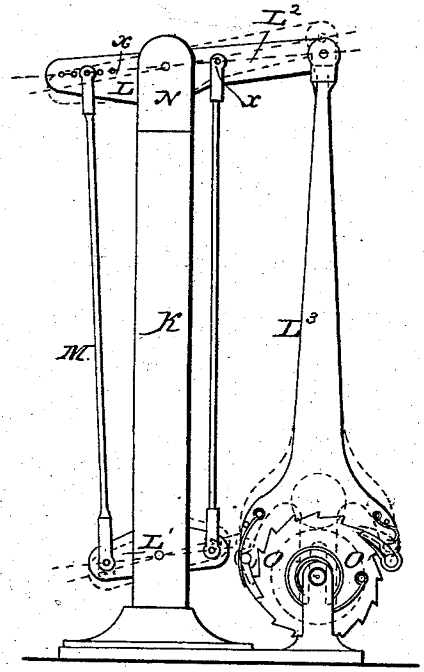

Fig. 2

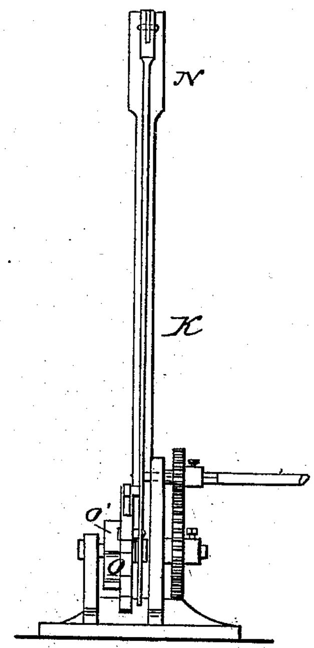

Fig. 3

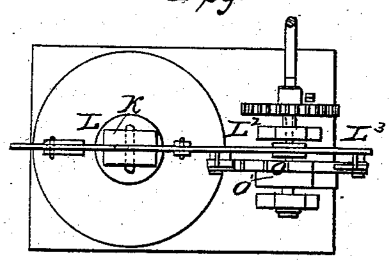

Fig. 7'

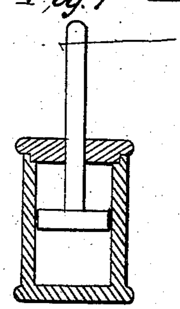

Fig. 7

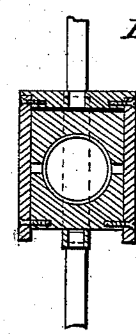

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Fig. 5 Fig. 4. Fig. 6.

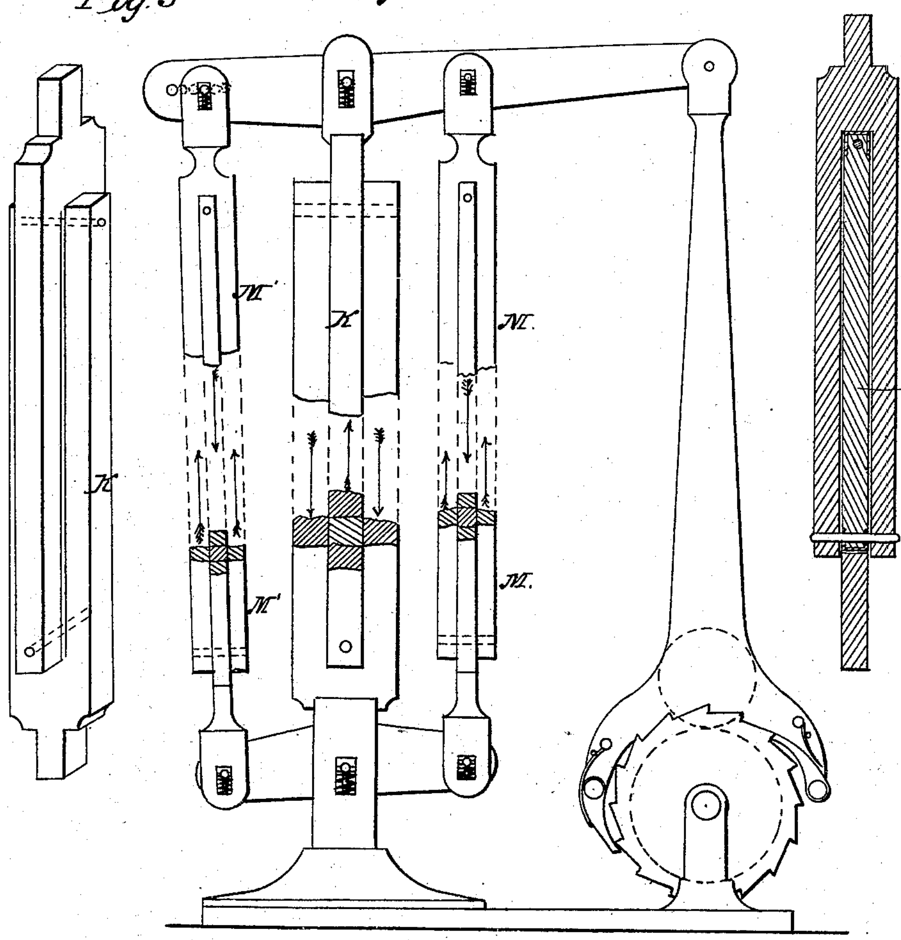

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Fig. 8.

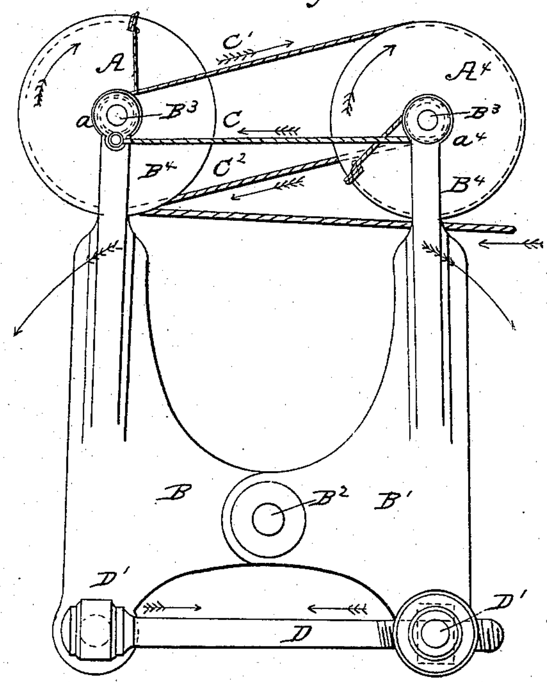

Fig. 10

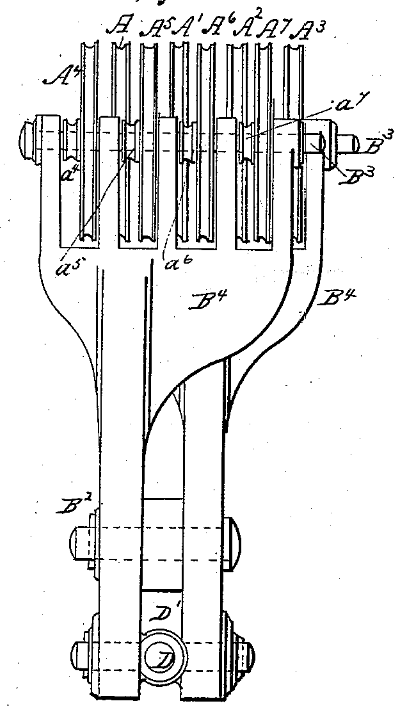

Fig. 9

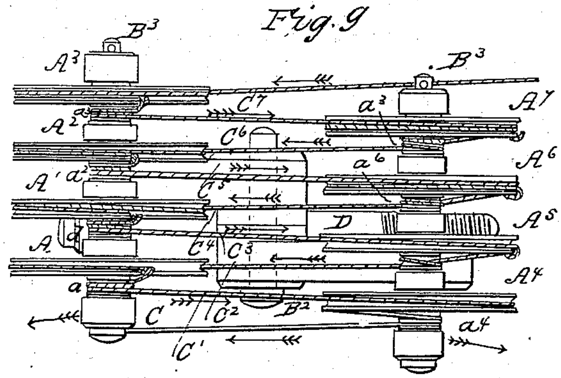

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Fig. 11

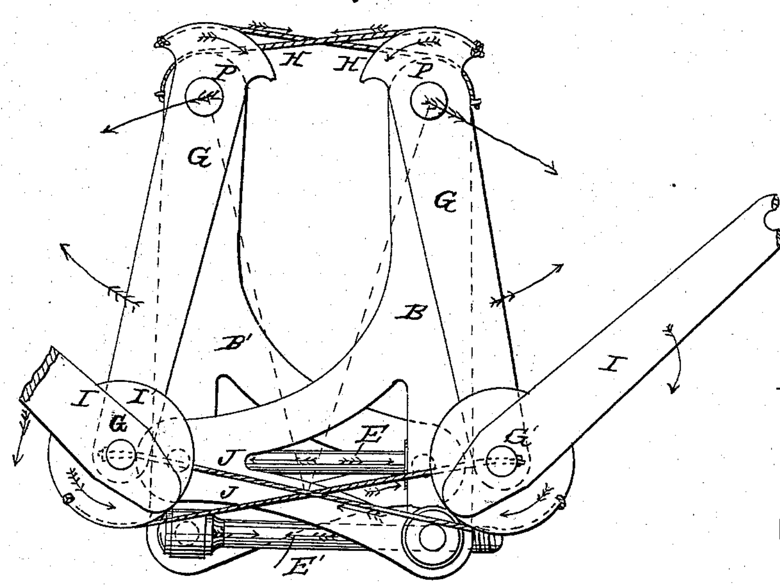


Fig. 12

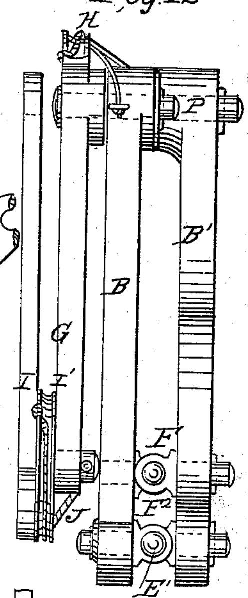


Fig. 14.

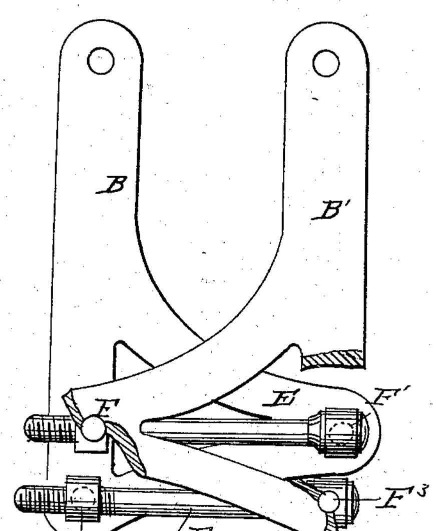
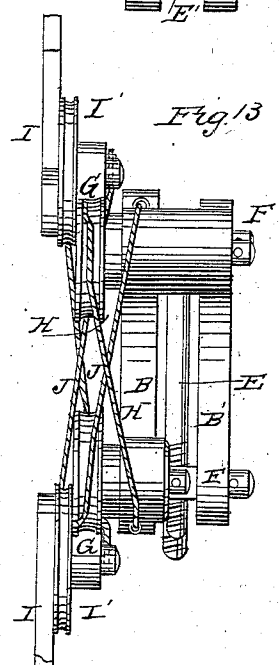


Fig. 13



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UNITED STATES PATENT OFFICE.

GEORGE I. WASHBURN, OF WORCESTER, MASSACHUSETTS.

THERMAL MOTOR.

Specification forming part of Letters Patent No. **48,607**, dated July 4, 1865.

To all whom it may concern:

Be it known that I, GEORGE I. WASHBURN, of the city and county of Worcester, and State of Massachusetts, have invented a new and improved thermal motor, or method of utilizing the expansive or contractile force developed in metals, fluids, &c., by the application of heat, natural or artificial, also of accumulating the effect of said expansion in such a manner that it may be used at will; and I do hereby declare the following to be a full and exact description of the same, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1 represents a side elevation of what may be considered the type of my invention. Fig. 2 is an end elevation, and Fig. 3 is a top view.

Similar letters of reference indicate corresponding parts in the several figures.

The fundamental feature of my invention consists in utilizing the two forms of heat: first, the costless form—for instance, natural variations of temperature occurring from day to day, or otherwise accidental variations of heat, such as the varying temperature of a room in winter; secondly, the artificial heat, by which I mean heat artificially generated or artificially applied. For this purpose I make use of the contraction and expansion of materials occasioned by the variation of their temperature, and as in many cases this range of contraction and expansion is very minute, but of immense power, an important feature of my invention is the way in which I multiply the motion, with a corresponding division of its force, and I either store the resulting force of this irregular variation by a suitable device—such as causing it to wind a mainspring—or use it directly.

In order that others skilled in the art to which my invention appertains may be enabled to fully understand and use the same, I will proceed to describe it.

K represents a vertical and rigid standard, through slots in which two levers, L L′, vibrate vertically. These levers are connected near their ends by rods M M′. Were these rods journaled to the levers at points equidistant from the points of vibration of the levers they would not produce the specific effect desired in this connection; but by pivoting the rod M′ to the lever L at a point more distant from the center of vibration of the lever than its corresponding rod on the other end of the lever a valuable effect is produced by the expansion or contraction of the rods by heat, as it elevates the extended limb of the lever L.

I will endeavor to explain the rationale of operation.

Supposing that the four points of attachment of the rods to the levers were equidistant from the respective points of vibration of the levers, and supposing the upper lever to be vibrated by an arrangement on the point ($x\,x$) of attachment to the connecting-rods, (see Fig. 1,) the motion of each point would be equal in a given time and the centers of vibration remain equidistant. Now change one of these points of attachment (say to x') to a position farther from or nearer to the center of vibration of its lever, and the difference between its motion and that of its fellow rod on the same lever (the motion of the other points being equal and not affecting the result) will cause the centers of vibration of the levers to approach to or recede from each other, according to the direction in which the vibration is made, and, conversely, it is plain that to advance or recede these said points of vibration would be to move the said lever at $x\,x$ in a corresponding degree and direction. Now, the contraction or expansion of the rods M, the central standard remaining immovable, must, viewed in the light of the fact that, having an equal retractive or expansive range, the points of attachment of the rods to the levers have an unequal arc to describe, of necessity either advance or recede the centers of vibration of the levers or vibrate the arm. In the diagram Fig. 1 the central standard, K, is supposed to be of a non-expansive material, and the motion shown in red lines is what would result from the contraction of the rods M. The upper lever is elevated in the air and made to produce any desired effect—as, for instance, turning the ratchet-wheel O and winding up the spring O′ through the medium of the connecting-rod L^3.

A modification of my invention is exhibited in Figs. 4, 5, 6, said modification consisting in a peculiar construction of the standard and of the rods M M′, by which the effect of the previously-described motor is augmented, and it is accomplished by combining wood and metals or other materials of different expansive power. Fig. 5 represents a substitute for the homogeneous arm M or M′ shown in the Figs. 1, 2, 3, its central portion, when it is desired to augment the expansive power, being made of wood, and the double fork-shaped pieces M M′ of metal. Between these forks is a bar of wood, N′, whose tendency to expand lengthwise with heat is comparatively trifling. Near the extremity of the legs of the forks they are bolted through the wood so firmly as to form a base for the contractile force. The fellow fork, embracing the other two faces of the rectangular bar of wood, is bolted by its extremities to the other end of the same bar. Thus within the given limit of length nearly double the expansive range is attained minus the slight amount of expansion of the wood. Contrariwise, by making the central bar of metal and the embracing forks of wood and attaching them in the same way to the central portion, the forks are pulled together by their ends and the general length diminished by the expansive power of heat. I use this method of adding to the expansive or contractile power of my rods or standards in such a way as to produce a greatly-augmented effect, as at Fig. 4.

It will be seen that underneath all the journals of the points of vibration of the levers and of attachment of the rods I place springs to keep the points from chattering. These springs are powerful beyond all the force that I require to exert, and will not give unless in case of such extraordinary expansion or contraction of the parts as might threaten to rupture the material.

In Fig. 7 I show a plan for producing a like effect by a bag or reservoir of liquid or air, which may be made to act in the same way as the combination of the wood and metal last spoken of, and this by being confined in a sac, cylinder, or other suitable way, the return motion, or that which is permitted by the contraction of the contained air, being made by a spring or weight which yields before the additional expansive force of heat, and that being removed restores the chamber to its original capacity,

I wish it distinctly understood that the introduction of the spring in any case is merely to balance the expansive force obtained by condensation, so that the apparatus, with its chamber of compressed air, may be in equilibrium when not subjected to variation by the application of heat, and the object of charging the chamber and then negativing its effects is to obtain within a limited space the practical advantage of a larger body of air than is due to the capacity of the vessel at ordinary pressure. Although this return force may be obtained by a weight or a metallic spring, yet it might, in the case of artificial application of heat, be desirable to make use of a pneumatic spring, as shown in Fig. 7′. The different parts may, however, be brought into more intimate relation in a single cylinder, as in Fig. 7′, with its piston, in which, the air on each side being equally condensed, one body of air may be subjected to the additional expansion due to the increase of heat, and the other act as a pneumatic spring, the expansive power being on one side of the piston and the pneumatic spring on the other, one valuable feature in this arrangement being that when in a state of equilibrium, rest, or disuse the two volumes of air have no tendency to leak past the piston, which can only occur when their expansion is relatively different. Also, by altering the heat of the pneumatic spring we may modify its relative power, forming an adjustable spring.

It will also be perceived that the functions of the air on each side of the piston may be relatively changed at will, and by an alternate application of means be made to produce a reciprocating motion.

I wish to remark that it will frequently be found desirable to use the expansion of a body of air or other analogous material, from the fact that in this case we get the effect of the whole cubical expansion minus the slight amount of additional cubical capacity of the containing-chamber due to its expansion, while in the use of bars of metal, &c., we only get the effect of the linear expansion; but, further, under some circumstances the bar might be the better mode, from its being more conveniently susceptible of high degrees of heat.

I will now proceed to describe other methods of multiplying and dividing the expansive motion of the materials used. I exhibit several plans for doing this.

Figs. 8, 9, and 10 represent, respectively, a side elevation, a plan, and an end elevation of a combination of devices illustrating my device for multiplying the motion. Figs. 11, 12, 13, and 14 illustrate a modification of the devices shown in Figs. 8, 9, and 10.

In Figs. 8, 9, and 10, B B′ represent two levers adapted to turn upon a pivot, B^2. Upon the long arms of these levers may be mounted eight wheels or pulleys, A A′ A^2 A^3 A^4 A^5 A^6 A^7, each lever being provided with a set or series of four. Formed in one piece with these pulleys are small concentric pulleys, *a a′*, and so on, the circumferences of the larger wheels being designed to serve as the long arms of levers and the smaller wheels as the short arms thereof. These multiplying-pulleys A *a* A′ *a′*, &c., are journaled or pivoted upon shafts B^3 B^3, which have their bearings in suitable frames, B^4 B^4 upon the upper ends of the levers B B′.

The wheels are connected together as follows: From the frame B^4 on the lever B extends a cord, wire, or chain, C, which is attached to the wheel a^4 in such a manner that its point of action will be at the under side of the wheel a^4. From the top of the wheel A^4 a cord, C′, extends to the under side of the wheel a; another, C^2, from the bottom of wheel A to the bottom of wheel a^5; another, C^3, from the top of wheel A^5 to the top of wheel a'; one, C^4, from the bottom of wheel A′ to the bottom of wheel a^6; one, C^5, from top of wheel A^6 to the top of wheel a^2; one, C^6, from the bottom of wheel A^2 to the bottom of wheel a^7, and one, C^7, from top of wheel A^7 to top of wheel a^3. These several cords or wires are wound around their respective wheels a sufficient number of times to prevent them from running out when the wheels are rotated. From the wheel A^3 a cord, C^8, may connect with the mechanism or device to which motion is to be imparted.

D represents a metallic rod, having its ends securely keyed in lugs or boxes D′ D′, which are pivoted in the short arms of the levers B B′, so that the latter may turn freely thereon when the rod is lengthened or shortened.

The connecting-cords of the multiplying wheels may be attached in a contrary manner from that illustrated in the drawings, so that when the centers B^3 B^3 are made to approach each other motion will be communicated to the wheels. When the rod D is diminished in length the motion thereby given the levers B B′ is communicated through the cord C to the small pulley a^4, and thence to the entire series through the connecting-cords C′ C^2, &c., the various parts moving in the direction indicated by the red arrows in Figs. 1 and 2. Each double wheel or pulley, in receiving and transmitting the motion from the levers B B′, multiplies it in a ratio commensurate with the difference between the radius of the large and small wheel (as A and a) composing said double wheel. Now, in addition to this, the first motion (which is the moving from or toward each other of the two centers B^3 B^3) is not only multiplied once by all the wheels, as before, but while the increase of the distance between A^4 a^4 and A a, or the centers of motion, is multiplied by all the wheels, the increase of distance between the centers of wheels A′ and A^5 is multiplied by the wheels A^6 a^6 A^2 a^2 A^7 a^7 A^3 a^3, and the increase of distance between the centers of A^6 a^6 and A^2 a^2 is multiplied by the wheels A^7 a^7 and A^3 a^3, the increase of distance between whose centers is added to the motion already produced in obtaining the motion given at the circumference of A^3. In order to obtain an equal result from an equal first motion in a system of multiplying-wheels whose centers should not change the relative positions, it would be requisite to employ, first, a set of eight double wheels of the same proportions as those above described; secondly, a set of six wheels turning with a velocity equal to that of the wheels A′ a' A^2 a^2 A^3 a^3 A^5 a^5 A^6 a^6 A^7 a^7; thirdly, a set of four wheels, and, fourthly, a set of two wheels. The resulting motion from these four different sets would, if added to each other, equal that produced by me in the manner explained.

It is apparent that the connection between the wheels may be made by means of cogs and in many other different ways from that represented.

By modifying the arrangement of the cords C C′, &c., the wheels may be rotated when moving either from or toward each other or in alternate opposite directions, and in either case the motion may be multiplied the same as in the arrangement described.

In the modification of my invention illustrated in Figs. 11, 12, 13, and 14, and which I will now proceed to describe, the levers B B′ are shaped somewhat like a boot, from which likeness I will denominate the points at which are attached metallic rods E E′ the "toe" and the "heel" of each lever, respectively. The rods E E′ serve to connect the levers B B′ at one end, and impart motion thereto by expansion or contraction in like manner with the rod D above described. One end of the rod E is firmly secured in a lug, F, which is pivoted in the toe of the lever B′, and the other end is secured in a lug, F′, which is pivoted in the toe of the lever B. The rod E′ is in the same manner connected to the respective heels of the levers B B′ by pivoted lugs F^2 F^3.

At the extremities of the long arms of the levers B B′ are attached levers G G by means of pivots P P, the short ends of which levers are connected by wires H H to either the long ends of the levers B B′, as illustrated, or to each other. The long arms of the levers G G carry pivots G′ G′, to which are secured levers I I, the short ends of which latter are connected by wires or cords J J attached to wheels I′ I′, which may be fastened to the levers in concentric position with the pivots G′ G′, and which may serve as additional means for multiplying the motion from the levers. The long arms of the levers I I may carry other similar levers, and thus the number can be increased to any desired extent.

It will be seen that by increasing the distance between the heels of the two levers B B′ the long arms thereof, with the pivots P P, will move toward each other, the levers rotating around a point located in the axis of the rod E and in the toe of each lever, respectively. Also, that by increasing the distance between the toes of the levers the long arms will move toward each in the same manner, and that each of the levers rotates around a point in its heel and in the axis of the rod B. Now, if the two rods A B become simultaneously lengthened to the same degree, the long arms of the levers will be made to move toward each other, the levers B B′ both rotating around the same point, which is located (vertically) half-way between the axis of the rods E E′ and (horizontally measuring) half-way between the toes and heels of the levers, as designated by the converging red lines in Fig. 4.

Fig. 11 clearly illustrates the operation of the above-described combination of multiplying-levers, the red arrows indicating the direction in which the various parts move.

The rods D E E′ may be either solid or tubular.

The substance whose expansive motion is made use of may be heated by numerous means, among which may be mentioned the following: first, by concentrating the rays of the sun; second, by combustion of fuel; third, by the injection of steam, hot air, gases, or hot liquids; fourth, by electric or galvanic action; fifth, by chemical action. If the connecting-wires of rods be stiff enough, a constant reciprocating movement of the levers could be obtained by alternately heating and cooling the rods.

The connecting wires or rods C C′ and H J may, if desired, be made of the same expanding material as the rods, so as to adapt them to not only transmit the power from lever to lever, but also act as motors themselves, with an effect governed by their location in the apparatus.

The above invention may be employed generally as a motor, either when the expansive and contracting motion of the material be previously stored or not, to run sewing-machines, time-keepers, music-boxes, generate a current of air through the medium of a blower. As employed in connection with the mainspring of a watch, it is adapted to wind up the same by the heat of the body, so that the watch may thus be made to run continually without any manipulation whatever.

Having thus described my invention, I wish it distinctly understood that I do not claim simply using the effective force derived from the expansion of a bar or other matter by heat, as that is to be found in automatic dampers, registering-thermometers, &c.; but

What I do claim as new, and desire to secure by Letters Patent, is—

1. Utilizing the expansive and contractile force derived from variations of temperature in tubes or bars of metal, so as to produce a regularly recurrent or continuous motion, the said force being applied through the intervention of a mainspring or resulting from the regularly recurrent artificial application of heat to said bar or tube.

2. Utilizing the expansive force resulting from the increase of temperature of a confined body of air to compress a spring from which a regularly recurring or continuous motion is obtained.

3. Utilizing the expansive force resulting from the artificially-produced increase of temperature of a confined body of air which is subjected to the variations of temperature without the accession of fresh air, excepting sufficient to supply the waste.

4. The double fork-shaped bars M M′ K, or their equivalent, embracing a central bar, N′, of a different expansive power, to which they are mutually attached at or near their extremities, by which the expansive power of a single rod may be almost doubled within a given length, and by which, according to the relative expansibility of the tongs and the embraced portion, it may be made to contract or to expand longitudinally by increase of temperature.

5. The levers B B′, multiplying wheels or pulleys A *a* A *a*′, &c., and expansible rod D, the whole being arranged to operate in the manner and for the purpose herein set forth.

6. A series of multiplying-levers, G I, operating, in connection with the levers B B′ and expansible rods E E′, in any manner substantially as described.

7. The connecting wires or cords C C, &c., H J, formed of metal or other material, and employed in combination with the multiplying wheels and levers, substantially as and for the purposes explained.

The above specification of my improved thermal motor signed this 29th day of April, 1864.

GEO. I. WASHBURN.

Witnesses:

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