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(71) Applicant: **KONE OY**
Munkkiniemen Puistotie 25
SF-00330 Helsinki 33 (FI)

(72) Inventor: **De Jong, Johannes**
Kauhajoenkuja 1
SF-04430 Järvenpää (FI)

(74) Representative: **Zipse + Habersack**
Kemnatenstrasse 49
D-80639 München (DE)

(54) Rope compensation for elevator.

(57) The invention relates to a compensation arrangement in an elevator (1) comprising an elevator car (2) and a counterweight (3), elevator suspension ropes (11) on which the elevator car (2) and the counterweight (3) are suspended, a traction sheave (5) whose motion is transmitted via the suspension ropes (11) to the elevator car (2) and to the counterweight (3), a car cable (4) and at least one diverting pulley (6). The compensation arrangement consists of at least one compensation loop (7a) for the elevator car (2), said loop being suspended from the elevator car (2) and a shaft wall, and at least one compensation loop (7b) for the counterweight (3), said loop being suspended from the counterweight (3) and a shaft wall. The circulation speed of the compensation loop (7b) for the counterweight (3) is half the travelling speed of the counterweight (3), and the circulation speed of the compensation loop (7a) for the elevator car (2) is half the travelling speed of the elevator car (2). The compensation loops (7a,7b) are attached to the shaft wall at a point at or above the midpoint of the path of the elevator car (2) or counterweight (3).

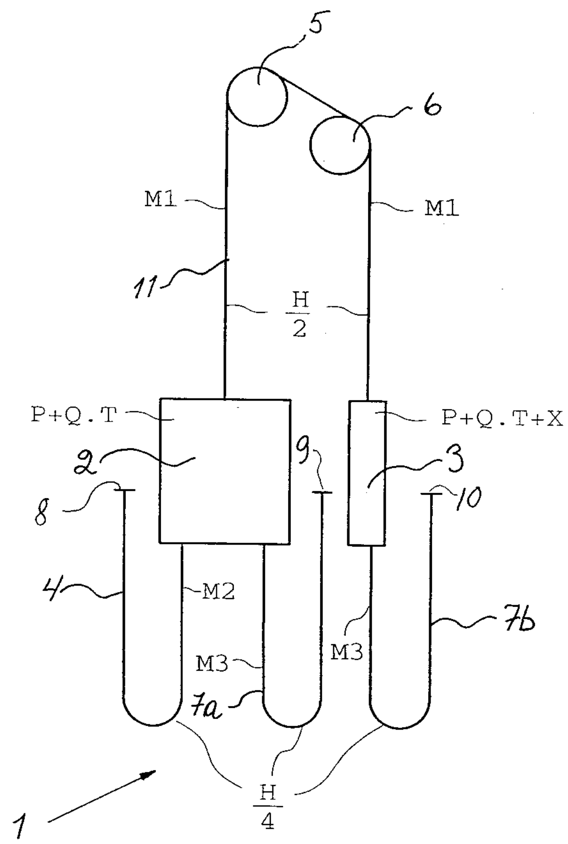

Fig.1

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The present invention relates to a compensation arrangement in an elevator as defined in the preamble of claim 1.

In high-rise buildings, elevators need to be provided with compensating ropes, belts or chains to offset the unbalance moment generated when the car is moving. If this were not done, motors of a considerably larger size would have to be used and the phenomenon would become worse wish increasing height. If the height in the shaft is increased sufficiently without rope compensation, a situation will occur where the friction is insufficient. In these, the compensation rope is fastened via a fixed wheel to the bottom of the shaft.

There are two different types of rope compensation. In the first type, a rope, belt or chain can be used, and these can be lined with rubber or plastic and they often contain additional masses attached to them. These ropes, belts or chains are mounted as loops below and between the car and counterweight and they are preferably attached to the lower parts of the car and counterweight. The range of application of this rope compensation is limited to relatively low speeds because of the danger of swinging. At the culmination of the loop, the speed of the rope, belt or chain is the same as that of the elevator. This speed occurring at the culmination point of the loop is called the loop circulation speed. Now, if the speed of the elevator is changed during acceleration or deceleration, then the speed of the loop will be changed as well and the cable starts to swing. The larger the speed range, the greater is the danger that the swinging will result in the rope, belt or chain being caught on a piece of shaft equipment.

In the other type of compensation, the additional masses used are generally a rope or ropes hanging in the form of loops below and between the car and counterweight. In addition, these loops are tightened by means of a tensioning device.

In this other type, swinging is prevented by using a guided tension weight. An example of known technology is e.g. the solution presented in US patent 3,653,467. Its drawbacks include a high cost and a complex structure.

The solution of the invention eliminates these drawbacks by rendering the expensive tension weight unnecessary and halving the loop speed as compared to the old loop. This is achieved by suspending the compensating ropes so that they run from the underside of the elevator car to fixing points in the wall and, similarly, from the underside of the counterweight to fixing points in the shaft wall. Thus, the compensating ropes are suspended in the same way as the car cable (= electricity supply, signalling and call button supply cable). Both compensation loops are attached to the shaft wall at a point at or above the midpoint of the path of the elevator car or counterweight. When the car moves in the down direction, both the car cable loop and the compensation loop move downwards and the loop circulation speed is only half the travelling speed of the car. Simultanously, the counterweight moves in the up direction and its compensation loop move upwards. The circulation speed of the counterweight compensation loop is half the travelling speed of the counterweight. Now that the compensating rope and the car cable are suspended in the same way, it is possible to combine their functions. This can be done e.g. by adding steel balls to the armature of the car cable as in Whisperflex (TM) compensation chain.

The invention provides considerable advantages:

- The loop circulation speed is only half the car speed, which means that swing is reduced significantly. This effect has been known before as it occurs in the car cable, which needs no guiding even at a high speed.
- The expensive tension device for swing damping is no longer needed.
- The cost of the compensation as a whole is about the same as for the present chain/belt compensation.
- Compensation can now be implemented by means of the car cable, part or all of which is used as a compensation loop.
- In very high buildings, no stopper for the prevention of counterweight bounce is needed if a solution according to patent FI 82823 is used, because the speed of the counterweight is lower and therefore also the counterweight bounce smaller.

In the following, the invention is described in detail by the aid of examples by referring to the attached drawings, in which

Fig. 1 presents a solution according to the invention when the car and counterweight are midway in the shaft,

Fig. 2 presents a solution according to the invention when the car is near the top of the shaft and the counterweight is near the bottom,

Fig. 3 presents a solution according to the invention when the car is near the bottom of the shaft and the counterweight is near the top,

Fig. 4 presents a solution in which the car cable and the compensation rope of the car are combined, and

Fig. 5 presents another solution according to the invention.

Fig. 1 illustrates the structure of the solution of the invention. It shows an elevator 1 with an elevator car 2 suspended to a ratio of 1:1 and a counterweight 3 suspended by means of a diverting pulley 6 to a ratio of 1:1 , elevator ropes 11 supporting the elevator car 2 and counterweight 3, and a traction sheave 5 whose motion is transmitted via the ropes to the elevator car 2 and counterweight 3. In this solution, the car cable 4 is preferably passed from the car 2 to a fixing point 8 in a wall of the elevator shaft, and the compensation loop 7a is also passed from the car 2 to a fixing point 9 in a shaft wall. Similarly, the compensation loop 7b below the counterweight 3 is attached to a fixing point 10 in a shaft wall. The compensation loops 7a and 7b are attached to the shaft wall at a point located at or above the mid-point of the path of the elevator car 2 or counterweight 3. The point of attachment of the car cable 4 is at the same height as that of the compensation ropes. The circulation speed of the compensation loop 7b for the counterweight 3 is half the travelling speed of the counterweight, and the circulation speed of the compensation loop 7a for the elevator car 2 is half the travelling speed of the car 2.

Let us now consider a situation where the elevator car 2 and the counterweight 3 are both located midway in the shaft. In this case, the mass of the elevator car 2 has been increased by an amount corresponding to the balancing perecentage of the counterweight, so the elevator car 2 should be in equilibrium with the counterweight 3. The brake of the machinery can now be released without the elevator car 2 and counterweight 3 getting in motion. This is only possible if the rope forces on the side of the elevator car 2 and on the side of the counterweight 3 are equal. In this position, the suspension ropes 11 on the side of the elevator car 2 and on the side of the counterweight 3 are about the same length, which is half the travel height H. The mass/measure of the hoisting rope is = M1. Below the elevator car 2 hangs compensation loop 7a. The loop length hanging from the elevator car 2 is at this point half the total loop length, i.e. about $\frac{1}{4}$ of the travel height H. The mass/measure of the car cable 4 is M2 and the mass/measure of compensation loop 7a is M3. The coun terweight 3 contains the mass of the elevator car 2 + balanc ing percentage * nominal load + a so-called cable setoff. Below the counterweight 3 hings the counterweight compensation loop 7b, in which the portion hanging from the counterweight 3 equals $\frac{1}{4}$ of the travel height H. The mass of this compensation loop, too, is M3/measure. The bare weight of the elevator car 2 is P, the nominal load is Q, the counterweight balancing degree is T, and X is an extra mass which is added to the counterweight 3 to achieve balance midway in the shaft.

The balancing formula is as follows:

$$P+Q * T+\tfrac{1}{2}H * M1+\tfrac{1}{4}H * (M2+M3) = P+Q * T+X+\tfrac{1}{2}H * M1+\tfrac{1}{4}H * M3 \quad (1)$$

Consequently, $X = \frac{1}{4}H * M2 \quad (2)$

From this equation (2), the extra mass X of the counterweight 3 is obtained.

With this extra mass x, balance is achieved.

Fig. 2 presents a situation where the car is near the top of the shaft and the counterweight is near the bottom.

The balancing equation is now as follows (3). When equation (2) is added to this

$$P+Q * T+\tfrac{1}{2}H * (M2+M3) = P+Q * T+X+M1 * H \quad (3),$$

we will obtain

$$P*Q * T+\tfrac{1}{2}H * (M2+M3) = P+Q * T+\tfrac{1}{4}H * M2+M1 * H \quad (4),$$

from which it follows that $M3 = 2M1-\frac{1}{2}M2 \quad (5)$.

Fig. 3 presents a situation where the car is near the bottom of the shaft and the counterweight is near the top.

The balancing equation is now formed as follows:

$$P+Q * T+H * M1 = P+Q * T+X+M3 * \tfrac{1}{2}H.,$$ to which equation (2) is added,

(2) $X = \frac{1}{4}H * M2$, and this leads to

$P+Q * T+H * M1 = P+Q * T+\frac{1}{4}H * M2+M3 * \frac{1}{2}H$, and consequently (6) $M3 = 2M1 - \frac{1}{2}M2$, which is the same as equation (5).

By using an extra mass $X = \frac{1}{4}H * M2$ and compensating mass $M3 = 2M1 - \frac{1}{2}M2$, a situation is achieved where the elevator is in equilibrium regardless of the position of the elevator car 2 and the counterweight 3.

Fig. 4 presents an alternative solution in which the car cable 4 can be used for compensation, either in part or entirely. If the car cable 4 is used for full compensation, we obtain a solution as presented in Fig. 4. In this example, the elevator car 2 is located midway in the shaft, extra mass X is zero and equation (2) yields M2 = 0. Also, from equations (4) and (6) we obtain M3 = 2 * M1. This means that we can use the car cable 4 for compensation.

Fig. 5 presents a solution which can be used in patents FI 82823. In this solution, the counterweight 3 is twice as heavy as in the above-mentioned figures 1-4 and the path and speed of the counterweight 3 are half those of the elevator car 2. Fig. 5 shows the elevator car 2 in its extreme positions. The result in this case, too, is a fully compensated solution. The mass/measure of the compensation loop 7b for the counterweight 3 is larger than the mass/measure of the compensation loop 7a for the elevator car 2. In the manner explained in connection with Fig. 1-4, the necessary equations can be solved by determining appropriate balancing equations for different solutions regarding the elevator car 2 and the counterweight 3. The equations depend on the location of the path of the counterweight 3, which may vary from case to case.

It is obvious to a person skilled in the art that different embodiments of the invention are not restricted to the examples described above, but that they may instead be varied within the scope of the claims presented below.

Claims

1. Compensation arrangement in an elevator (1) comprising an elevator car (2), a counterweight (3) and elevator suspension ropes (2) on which the elevator car (2) and the counterweight (3) are suspended, and a traction sheave (5) whose motion is transmitted via the suspension ropes (11) to the elevator car (2) and to the counterweight (3), and optionally a car cable (4) as well as at least one diverting pulley (6), characterized in that

- the compensation arrangement consists of at least one compensation loop (7a) for the elevator car (2), which compensation loop is suspended from the elevator car (2) and a wall of the shaft, and at least one compensation loop (7b) for the counterweight (3), which compensation loop is suspended from the counterweight (3) and a wall of the shaft, and that
- the compensation loops (7a, 7b) are attached to the shaft wall at a point located at or above the midpoint of the path of the elevator car (2) or counterweight (3).

2. Compensation arrangement according to claim 1, **characterized** in that the car cable (4) is used either partly or entirely as a compensation loop for the elevator car (2).

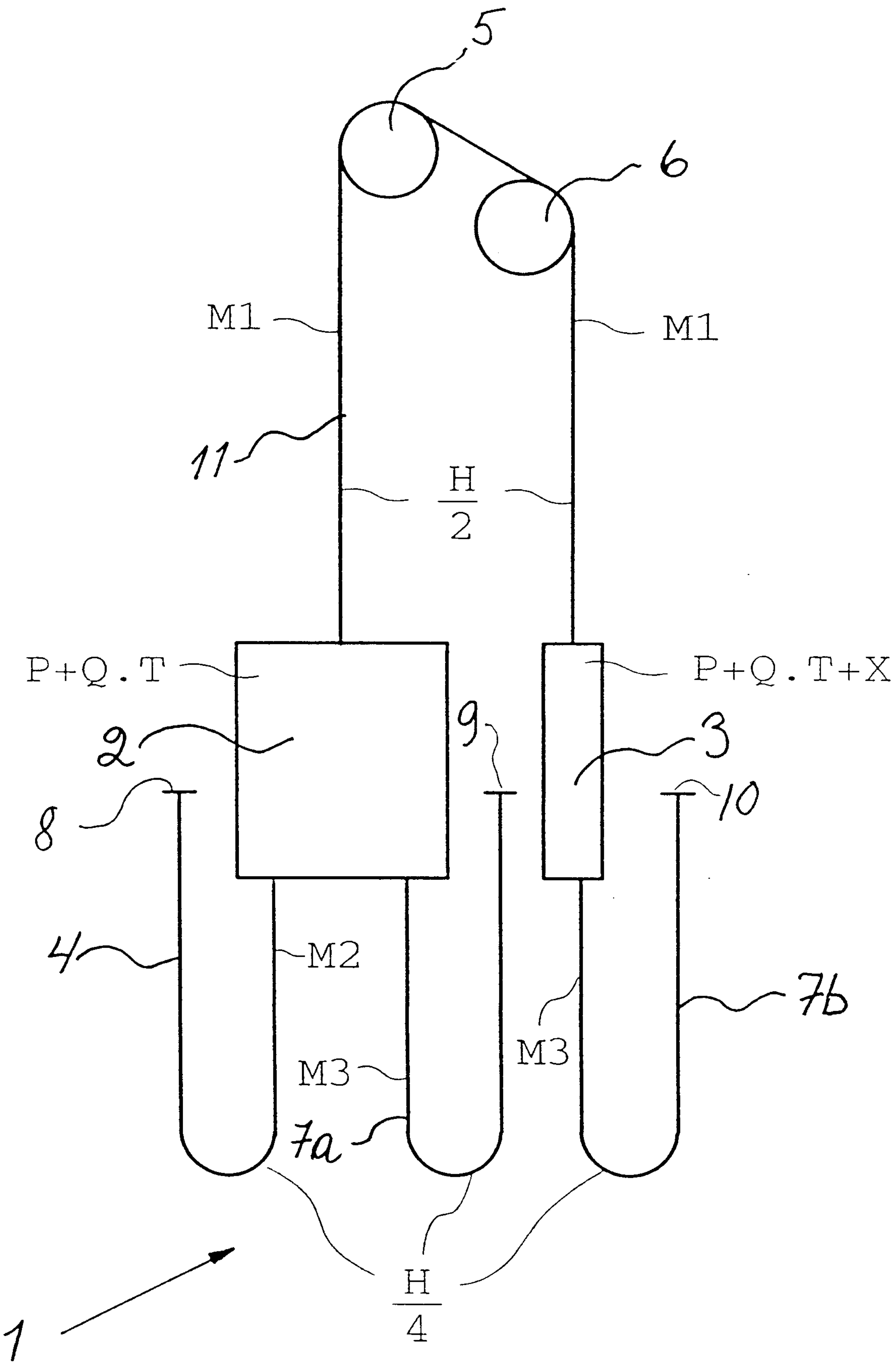

Fig.1

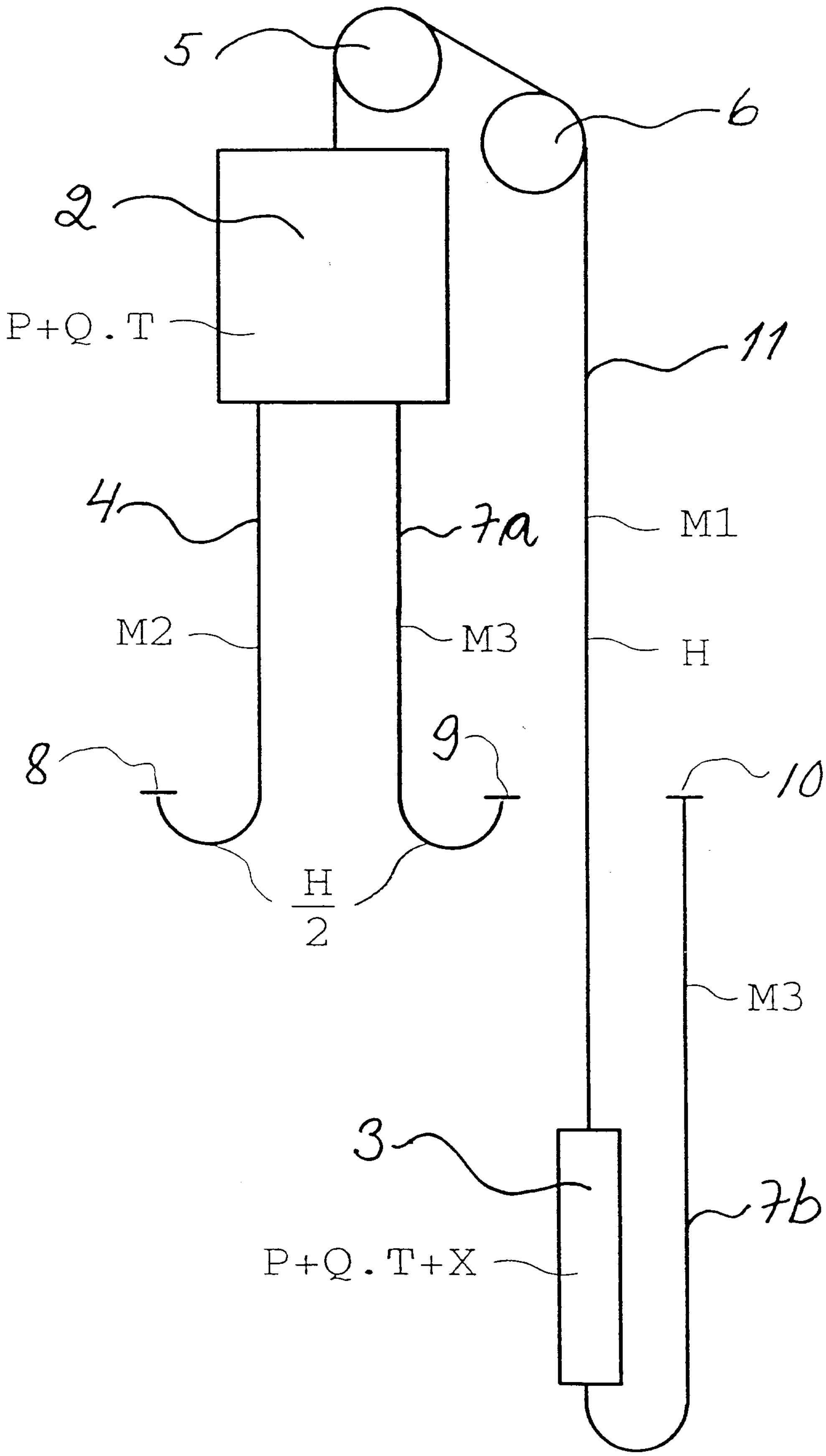

Fig. 2

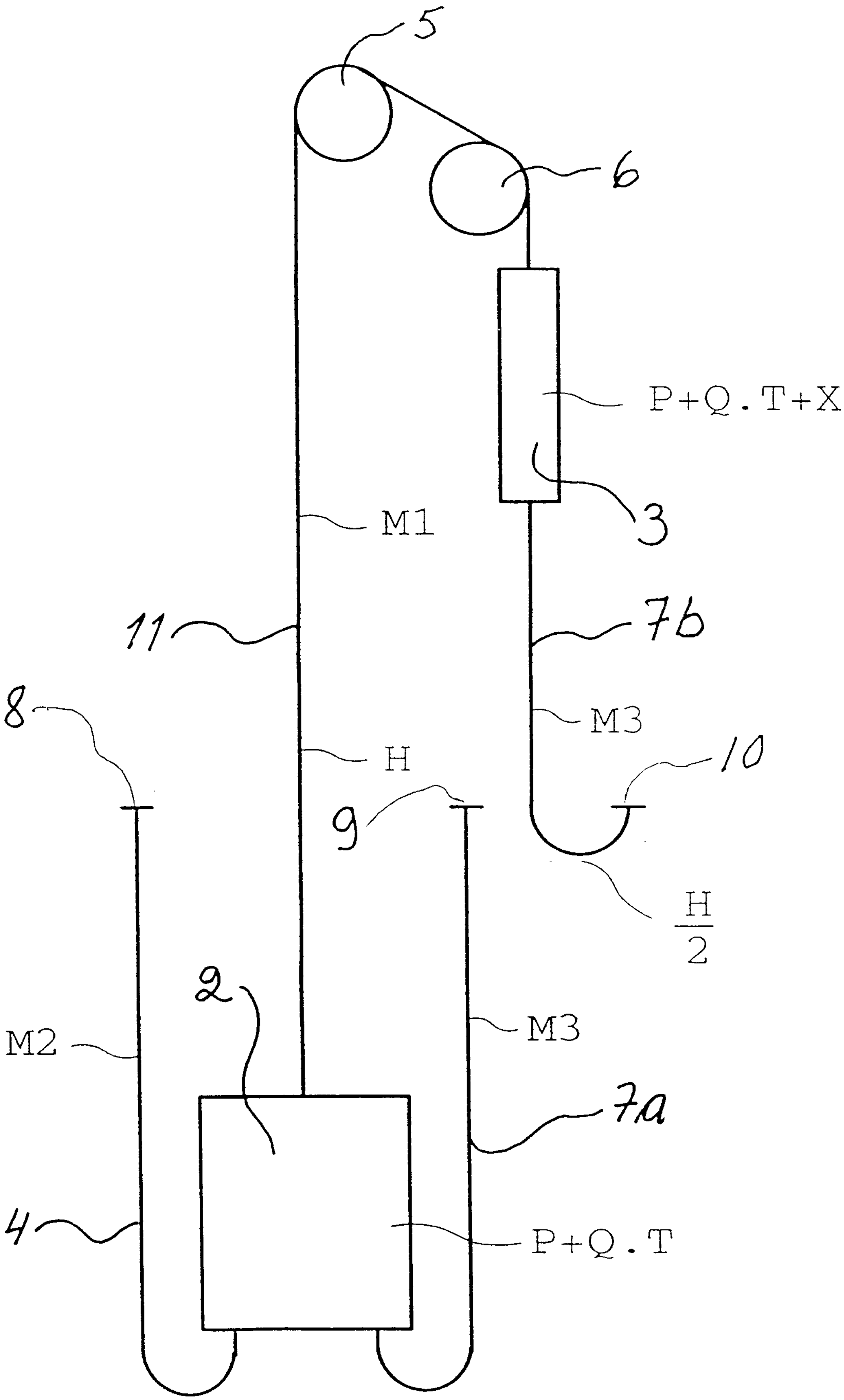

Fig.3

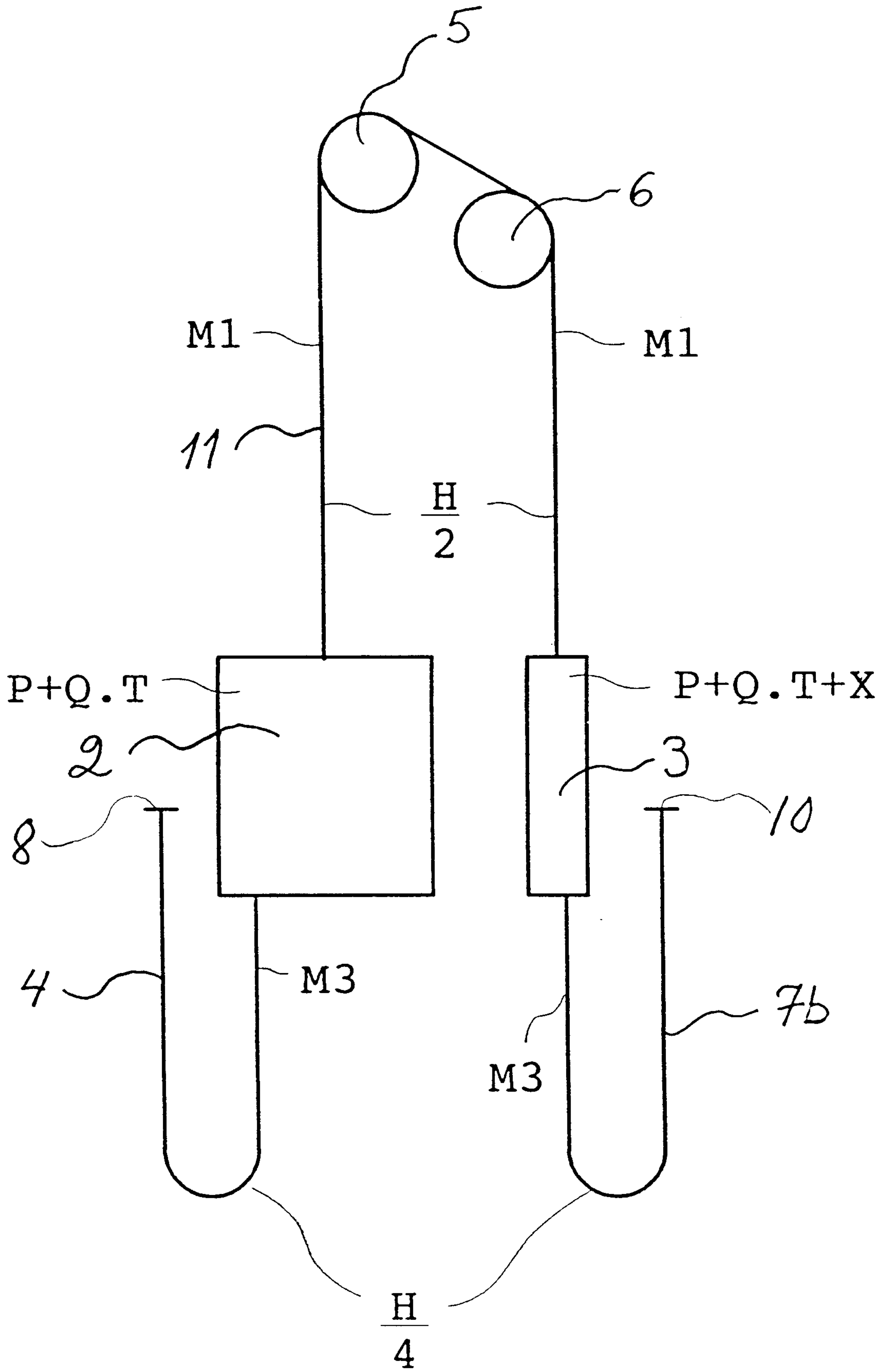

Fig. 4

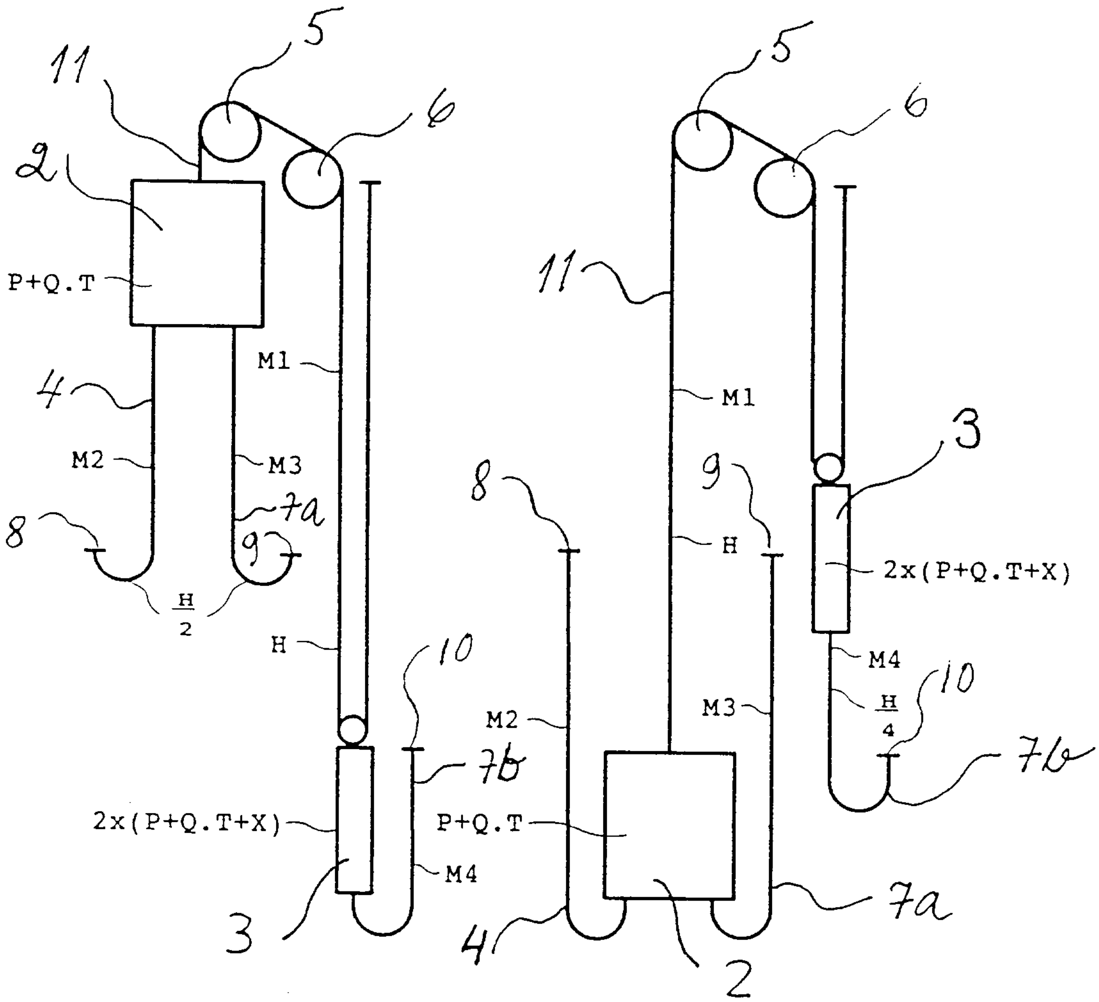
11
5
6
2
P+Q.T
M1
4
M2
M3
7a
8
9
H/2
H
10
7b
2x(P+Q.T+X)
M4
3
5
6
11
M1
3
8
9
H
2x(P+Q.T+X)
M4
H/4
10
7b
M2
M3
P+Q.T
4
2
7a

Fig. 5