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SOLUTIONS FOR THE PROBLEM OF THE SEMI-INFINITE BODY

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ABSTRACT
The purpose of this paper is to investigate the effect of the finite speed of hear transfer on the temperature distribution and heat flux for the case of a step change in temperature at the surface of a semi-infinite body. In the solution, the properties C and α are assumed constant. The solution yields a maximum but finite heat flux under the conditions of a step change. This a contrary to the infinite value predicted by the error function solution to the Fourier transient conduction equation. In addition, assuming convection is conduction limited; an upper limit for convective heat transfer coefficients is postulated.
Key words: milling machines, balanced, hydraulic, weight, gravity center

1. INTRODUCTION
Special problems occur on balance systems in case of large sized machine tools (were heavy sub-assemblies are to be moved vertically, such as: portal type milling machines, quill type boring and milling machines, single column type vertical lathes, etc.).
The classical design used two cast iron counter-weights sliding inside of each two columns. Their total weight is, fig. 1:

$$G_{tot} = 1.1\ (G_t + G_c + F_{ft}), \tag{1}$$

where:

G_{tot} = counter-weight total weight;
G_t = cross rail weight;
G_c = milling head weight;
F_{ft} = friction force of the cross rail motion.

The solution of above solves the following issues:

- The cross rail keeps constant the resulting direction of its own gravity center.
- The milling head, along with its slide move horizontally while working and means approx. 40% of the entire sub-assembly to be balanced change horizontally the position of the gravity center, whilst the counter-weights have a fixed position. It will result that, for different positions of the milling head on the cross rail, the requirements (and, by default, elongations) of the drawing cables are different. The consequence is obvious: the cross rail will be changing its horizontal position it had been adjusted to. This leads to the following:

Eccentrically requirement of the lead screws (early wear, etc)
Losing the geometrical accuracy in vertical plane, with implications on the machining quality.

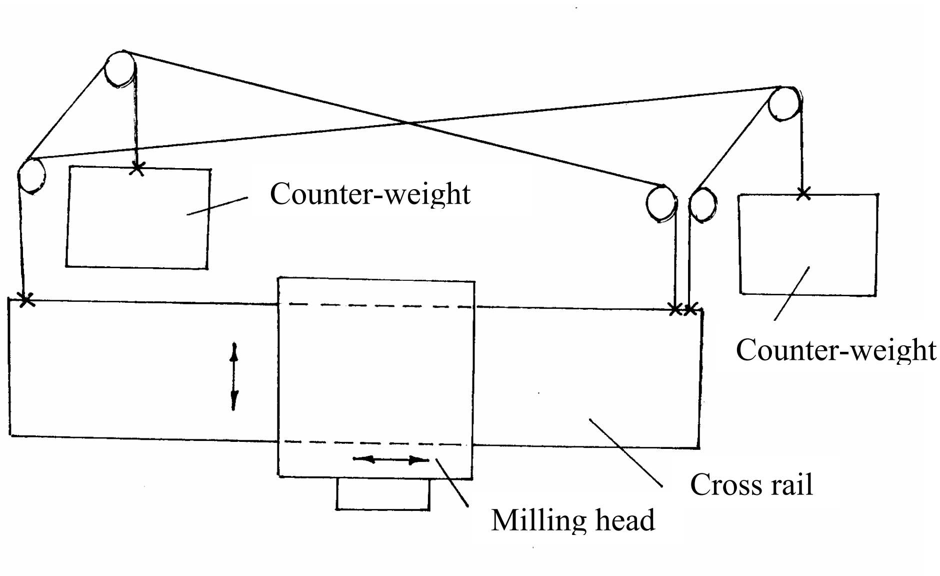

Figure. 1

In case of a numerically controlled machine, the movement of a sub-assembly along its must comply with several more demanding requirements, so that a proper balance is a must and needs to be more rigorously done. Most of the reputed brands in such machine types (Line, Waldrich, Morey, etc) are using two hydraulically cylinders for balancing the milling head, that are directly supporting on this slide.
Actually, as shown above, the cross rail balance consists of balancing the entire system: milling head, its slide and cross rail itself. If the length of the cross rail is considered (as the clearance between columns night reach 3000 ÷ 4000 mm) as well as that it has to support the milling head and slide weight (8000 ÷ 15000 kgf), it will result a cross section of high axial torque and, by default, a heavy weight.
Accordingly, in the case of a CNC machine, the respective axes have a long response time, that leads to deviations of the tool path when the machine is requirement to make horizontal and vertical contouring.

The solution being shown in fig. 2 is intended just for solving part of the deficiencies mentioned above. The system is based on a pulley set, chosen so that the sun of the milling head and cross rail motions to be half on the pulley of each piston of the off-set cylinder. Also, the carriage *4* is provided, that moves along the cross rail *5*. The tour pulleys are borne on the carriage *4*.
The carriage motion is synchronized with the horizontal movement of the milling head through the command taken from a hydraulic manifold *8*. On its turn, this manifold is actuated by a follow-up rod of one of the cables (ropes).If this rope deviates from verticality, that will mean that a movement synchronization had come up, which will be corrected by changing the manifold shelf position, that will command the rotation of the hydraulic motor *11*, located on the support *4* on the milling head.

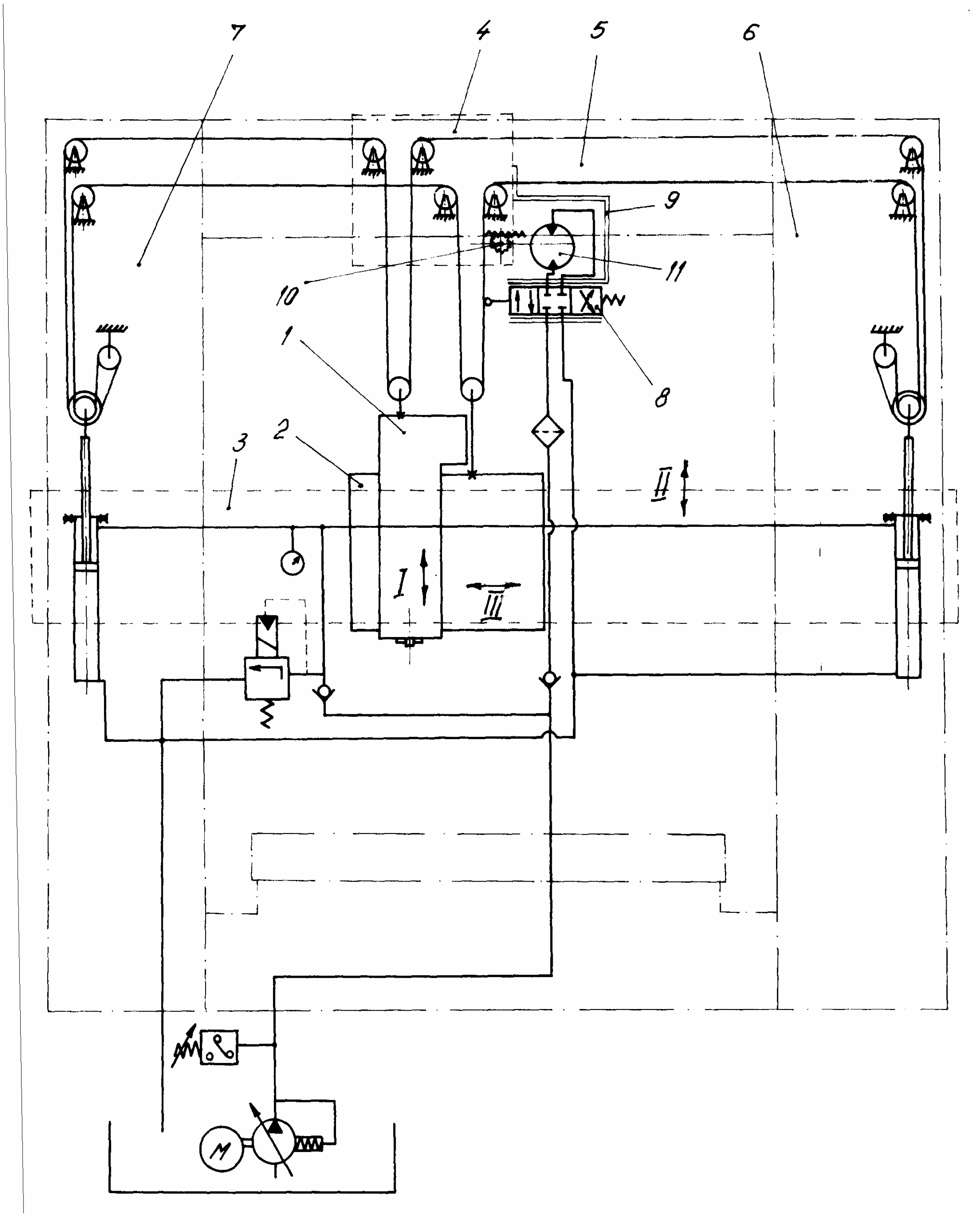

Figure 2.
1 - milling head; 2 – milling head slide; 3 – cross rail; 4 – carriage; 5 – fixed rail; 6,7 – columns; 8 – follow-up shelf; 9 – support; 10 – rack-pinion mechanism; 11 – rotary hydraulic motor.

The hydraulic motor, through its pinion-rack mechanism, gives the correction motion to the carriage *4* bearing the four pulleys.

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