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KINEMATIC ANALYSIS OF A CAM MECHANISM WITH ELASTIC ELEMENTS OF THE MECHANISM WITH ELASTIC ELEMENTS OF PAIRED CAMS OF A BOEL MECHANISM OF A WEAVING LOOM

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Abstract: The article provides a diagram and principles of operation of the crank mechanism with composite cams. The results of the kinematic analysis of the mechanism with compound cams are presented, taking into account the maximum deformations of the elastic elements of the composite cams of the cam mechanism of the weaving loom. Analytical expressions describing the laws of motion of the connecting rod and rocker arm of a replacement linkage-joint mechanism with their four-link length changing are given. The kinematic characteristics of the crank mechanism with composite cams have been analyzed, and the main parameters of the system have been substantiated.

Keywords: Cam mechanisms, fastened elastic element, pusher, connecting rod, rocker arm, angular movements, speed, screws, maximum deformation, elongation, rigidity, loom, transformation.

Introduction. The design of the baton mechanism is known, which contains a baton, the main shaft of the loom with a cam and a counter-cam, the sub-battan shaft of the loom and has, on the batan shaft of the loom, a cam unloader consisting of a cam along which a roller moves, hinged on a swinging rocker arm connected by one one end with a spring, and the other end hinged on the bed of the loom. In this design, the cam unloader spring acts as an energy storage device for the drum. The cam of the cam unloader performs the function of controlling the distribution of energy by the accumulated spring and transferring energy from the spring required to completely balance the inertia forces of the baton and create a backlash-free swinging movement of the baton [1].

The disadvantage of this mechanism is the complexity of the design, as well as limited speed modes due to the inclusion of an additional cam mechanism with a spring unloader.

Methods.In the known design of a weaving baton, for equalizing power in the baton mechanism of the weaving machine, it contains a baton with a reed installed on a baton shaft, a kinematic baton drive connected to the main shaft of the machine, geometrically closed with the baton to impart a forced, backlash-free reciprocating movement to the latter, at least one energy accumulator, one of the ends connected to the baton. The energy accumulator is fixed at the other end to accumulate the kinematic energy of the baton and reduce the drive torque of the drive. [2].

The disadvantage of this mechanism is also the complexity of the design and reduced driving conditions due to the complex vibrations of the spring shock absorbers.

According to research results, it is known that the beating force of the weft thread reaches up to 800-800 N and this leads to the emergence of reaction forces in the supports of the weft shaft. In addition, significant values of the impact force to some extent limit the increase in machine productivity [3].

Structural diagram and principles of operation of a crank mechanism with cams coupled with elastic elements.

Another baton mechanism of a loom, consisting of a cam and a counter-cam coupled with it (paired), mounted on the main shaft, two rollers in contact with the cam profiles, hingedly mounted on a three-arm lever, and the third arm of the lever is the batan blade, to which the baton beam is attached, reed bearer. The lever is mounted on the drive shaft and swings in both directions [4].

The disadvantage of this design is that during the back-and-forth motion of the baton, unbalanced inertial forces arise in the mechanism, which lead to an increase in reactions in kinematic pairs and uneven rotation of the main shaft of the loom. As a result, the law of motion of the batan differs from the designed law of motion. In addition, under the influence of the inertia forces of the baton, during one revolution of the cam, the contact of the batt rollers from the cam to the counter-cam occurs twice, which causes shocks in the loom mechanism and increased vibration. In addition, the surfaces of the cams and rollers wear out, reducing the service life of the mechanism.

A well-known baton mechanism of a weaving loom, containing a cam and an associated counter-cam installed on the main shaft, in contact with the profiles of the cams, two rollers mounted pivotally on a three-arm lever mounted on the baton shaft, the third arm of the lever connected to a batten beam carrying the reed, and the rollers are made composite, and each roller contains a hinge, an elastic rubber bushing mounted on it and an outer bushing, and the thickness of the elastic rubber bushing of the roller in contact with the cam is twice as large as the thickness of the elastic rubber bushing of the roller in contact with the counter cam, while the three-arm lever is connected to the main one shaft by a torsion spring [5].

The design was adopted as a prototype, according to [4].

The objective of the invention is to increase the reliability of the design and performance of the weaving machine.

The problem is solved by improving the design of the cams and counter-cam of the baton mechanism with the inclusion of elastic elements.

Results. The essence of the design is that the baton mechanism of the loom contains a cam and a countercam paired with it, mounted on the main shaft, two rollers in contact with the cam profiles, hingedly mounted on a three-arm lever mounted on the batt shaft, the third arm of the lever is connected to the batt beam, bearing the reed, while the cam and counter-cam are made composite, including a base and an outer ring with a curved profile, and a rubber ring also with a curved shape is installed between them. The connection of the bases with the outer ring of the curved profiles is carried out with special glue. At the same time, during operation, due to the use of ring rubber shock absorbers, a soft interaction of the rollers with the cams occurs. As a result, friction, wear and noise are reduced, and the reliability of the mechanism increases. It becomes possible to increase the productivity of tissue formation.

The proposed design is illustrated by a drawing, where in Fig. 1 a is the general diagram of the baton mechanism, in Fig. b - section A-A of Fig. 1

Disscussions. The design contains a housing 1, a cam 2, a counter-cam 3, installed on the main shaft 4. In this case, the cam 2 and the counter-cam 3 are made of composite parts, the cam 2 consists of an outer ring 17 with a curved profile and a base 16, also with a curved profile, and between them is installed rubber ring 18 with an identical curved profile, connected to each other with special glue. The counter cam 3 connected to the cam 2 is also made of an outer ring 14 with a curved profile, a base 13 with a curved profile, and between them there is a rubber ring 15 with a curved profile, which are connected to each other with special glue.

The outer curved profiles of the outer rings 14 and 17 are in contact, respectively, with rollers 5 and 6, mounted by hinges 7 on three arms, levers 8 and 9 mounted on the shaft 11, the third arm 10 of the lever is connected to the bearing beam 12. Elastic rubber rings 15 and 18 are made made of oil-resistant material. (Fig.1)

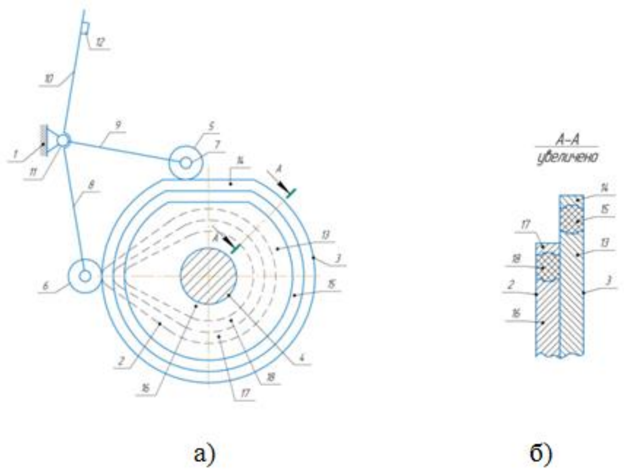


Fig.1. Batt mechanism of weaving loom.

The baton mechanism works as follows. The rotational movement of cam 2 and the counter cam 3 paired with it is received from the main shaft 4. In this case, the three-arm lever (pusher) receives a rocking motion due to the constant contact of rollers 5 and 6 with the profiles of cams 2 and 3. This movement is transmitted to the beam (lever arm 7) 10 with birdie 12.

During operation of the drum mechanism, rollers 5 and 6 interact with the curved profiles of the outer rings 4 and 17 of cams 2 and 3. In this case, pressure forces arise due to the weight forces and the variability of the radii of cams 2 and 3. Elastic rubber rings 15 and 18, deforming, absorb the forces pressure between rollers 5 and 6 and outer rings 14 and 17. The maximum values of these forces occur at the moment of weft thread breaking. Cam 2, through roller 6, the shoulders of three lever arms 7, beam 10 and reed 12, provides the main process of beating the weft thread. Therefore, the rigidity of ring 18 is chosen greater than the rigidity of ring 15.

The design allows for a reduction in the load on the main 4 and the main shaft 11, reduces noise, increases reliability, and thus makes it possible to increase productivity.

Kinematics of a cam mechanism with composite cams and elastic elements. During the process of fabric formation in a weaving loom, some dwell time is required with a slight oscillation of the end of the beam (reed). To obtain such a pattern of movement of the pusher, a cam with elastic elements is used in the drum mechanism [6,7]. In this case, due to the deformation of the elastic element of the composite cam, the position of the cam profile changes. This causes some vibration at the end of the pusher. Berda will carry out the required laws of motion. In this case, it is important to determine the kinematics of the characteristics of the movement of the rocker arm, taking into account the maximum deformations of the elastic rings of the paired cams of the baton mechanism. To do this, the cam mechanism is replaced by a four-link lever mechanism. In the kinematic pore of the fourth class, two kinematic pairs of the fifth class are introduced, the cam is replaced by a crank and connecting rod [8,9].

Deformations of elastic rings are taken into account only by maximum values [10]. The design diagram of the replacement mechanism, taking into account the maximum deformations of the elastic rings of the rear cams, is presented in Fig. 2.

Using the well-known closed vector method [11], we obtained equations to determine the angular displacements φ_2 and φ_3.

In the mechanism under consideration, we will compose vector equations for the contours ABD and BCD:

for ABD circuit:

$$\bar{l}_4 + \bar{q} - \bar{e}_1 = 0 \tag{1}$$

for circuit BC ABD:

$$\bar{q} + \bar{l}_2 - \bar{l}_3 = 0;$$

$$\bar{q} + \bar{l}_2 + \Delta\bar{l}_2 - \bar{l}_3 - \Delta\bar{l}_3 = 0;$$

$$\bar{q} + \bar{l}_2 - \Delta\bar{l}_2 - \bar{l}_3 - \Delta\bar{l}_3 = 0 \tag{2}$$

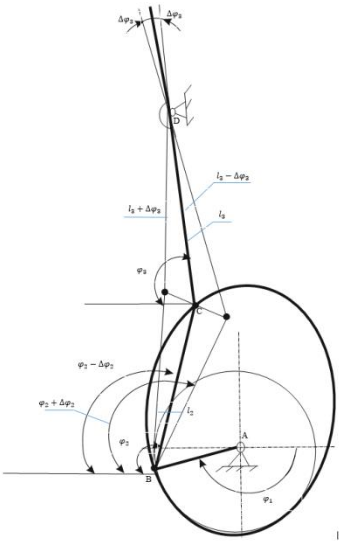


Fig. 2. Diagram of the replaceable cam mechanism of the loom batan.

At the same time, projecting the vectors of equation (2) on the coordinate axes x and y we have: [12, 13].

$$l_4+q\cos\varphi_q-l_1\cos\varphi_1=0$$
$$q\sin\varphi_q+l_1\sin\varphi_1=0 \qquad (3)$$

According to the methodology given in [13,14], from (3) we have:

$$tg\varphi_q=\frac{l_1\sin\varphi_1}{l_4-l_1\cos\varphi_1}; \quad q=-l_1\frac{\sin\varphi_1}{\sin\varphi_q} \qquad (4)$$

Taking into account the values of $\Delta l2$ and $\Delta l3$ for the corresponding angles *BCD* using the cosine theorems we have [15]:

$$l_2^2=q^2+l_3^2-2ql_3\cos\varphi_{3q};$$
$$l_3^2=q^2+l_3^2-2ql_2\cos\varphi_{2q};$$
$$(l_2+\Delta l_2)^2=q^2+(l_3+\Delta l_3)^2-2q(l_3+\Delta l_3)\cos(\varphi_{3q}+\Delta\varphi_3); \qquad (5)$$
$$(l_3+\Delta l_3)^2=q^2+(l_2+\Delta l_2)^2-2q(l_2+\Delta l_2)\cos(\varphi_{2q}+\Delta\varphi_2);$$
$$(l_2-\Delta l_2)^2=q^2+(l_3-\Delta l_3)^2-2q(l_3-\Delta l_3)\cos(\varphi_{3q}-\Delta\varphi_3);$$
$$(l_3-\Delta l_3)^2=q^2+(l_2-\Delta l_2)^2-2q(l_2-\Delta l_2)\cos(\varphi_{2q}-\Delta\varphi_2);$$

In this case we have:

$$\varphi_{3q}=\arccos\frac{q^2+l_3^2-l_2^2}{2ql_3}; \qquad \varphi_{2q}=\arccos\frac{q^2+l_2^2-l_3^2}{2ql_2};$$

$$\varphi_{3q}+\Delta\varphi_3=\arccos\frac{q^2+(l_3+\Delta l_3)^2-(l_2+\Delta l_2)^2}{2q(l_3+\Delta l_3)};$$

$$\varphi_{2q}+\Delta\varphi_2=\arccos\frac{q^2+(l_2+\Delta l_2)^2-(l_3+\Delta l_3)^2}{2q(l_2+\Delta l_2)};$$
$$\varphi_{3q}-\Delta\varphi_3=\arccos\frac{q^2+(l_3-\Delta l_3)^2-(l_2-\Delta l_2)^2}{2q(l_3-\Delta l_3)};\qquad(6)$$
$$\varphi_{2q}-\Delta\varphi_2=\arccos\frac{q^2+(l_2-\Delta l_2)^2-(l_3-\Delta l_3)^2}{2q(l_2-\Delta l_2)};$$

We obtain the patterns of angular displacements in the form:

$$\varphi_3=\arccos\frac{l_1^2-l_2^2+l_3^2+l_4^2-2l_1l_4\cos\varphi_1}{2l_3\sqrt{l_1^2+l_4^2-2l_1l_4\cos\varphi_1}}+arctg\frac{l_1\sin\varphi_1}{l_4-l_1\cos\varphi_1}\qquad(7)$$
$$\varphi_2=\arccos\frac{l_1^2+l_2^2-l_3^2+l_4^2-2l_1l_4\cos\varphi_1}{2l_2\sqrt{l_1^2+l_4^2-2l_1l_4\cos\varphi_1}}+arctg\frac{l_1\sin\varphi_1}{l_4-l_1\cos\varphi_1}$$

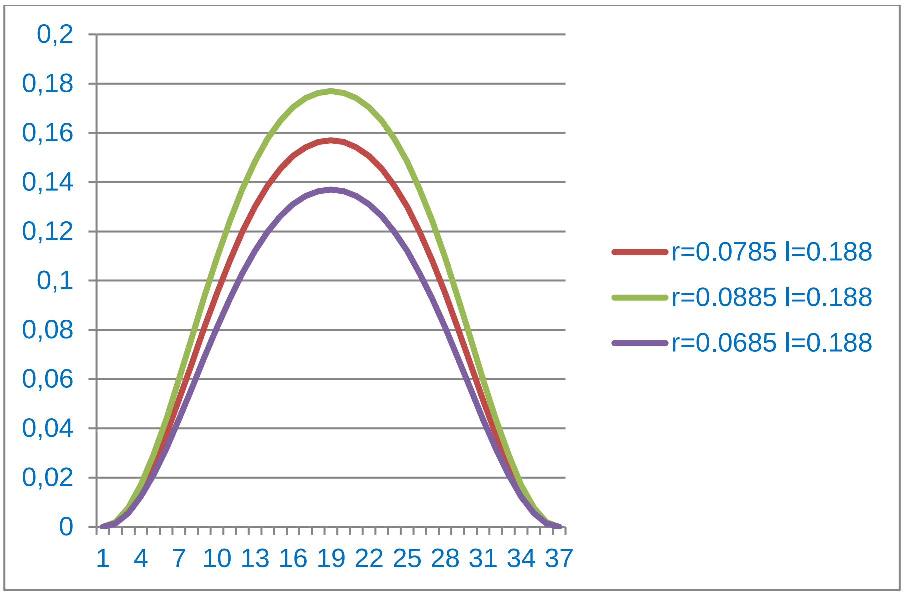
Taking into account the deformation of the elastic element, the determination of values $\Delta\varphi_2$ and $\Delta\varphi_3$ is considered cyclic, taking into account the length of the driver (connecting rod) and the blade (rocker arm) of the baton mechanism of the loom. In this case, subtracting the third equation from the first equation (7) and dividing by two, as well as subtracting from the second equation and dividing by two, we obtain the following expressions:

$$\Delta\varphi_3=\frac{1}{2}\left[\begin{array}{l}\arccos\dfrac{l_1^2+l_4^2-2l_1l_4\cos\varphi_1+(l_3+\Delta l_3)^2-(l_2+\Delta l_2)^2}{2(l_3+\Delta l_3)\sqrt{l_1^2+l_4^2-2l_1l_4\cos\varphi_1}}-\\ -\arccos\dfrac{l_1^2+l_4^2-2l_1l_4\cos\varphi_1+(l_3-\Delta l_3)^2-(l_2-\Delta l_2)}{2(l_3+\Delta l_3)\sqrt{l_1^2+l_4^2-2l_1l_4\cos\varphi_1}}\end{array}\right]\qquad(8)$$
$$\Delta\varphi_2=\frac{1}{2}\left[\begin{array}{l}\arccos\dfrac{l_1^2+l_4^2-2l_1l_4\cos\varphi_1+(l_2+\Delta l_2)^2-(l_3+\Delta l_3)^2}{2(l_3+\Delta l_3)\sqrt{l_1^2+l_4^2-2l_1l_4\cos\varphi_1}}-\\ -\arccos\dfrac{l_1^2+l_4^2-2l_1l_4\cos\varphi_1+(l_2-\Delta l_2)^2-(l_3-\Delta l_3)}{2(l_2-\Delta l_3)\sqrt{l_1^2+l_4^2-2l_1l_4\cos\varphi_1}}\end{array}\right]$$

According to the design diagram in Fig. 2... we can write:

$$\varphi_{3\max}=\varphi_3+\Delta\varphi_3;\qquad\varphi_{3\min}=\varphi_3-\Delta\varphi_3;$$
$$\varphi_{2\max}=\varphi_2+\Delta\varphi_2;\qquad\varphi_{2\min}=\varphi_2-\Delta\varphi_2\qquad(9)$$

Numerical solution of the problem posed in the form of the law of conditional movement of the rocker arm (reed) of the cam batan of the loom mechanism. In Fig. Figure 3 shows the patterns of movement of the rocker arm in the absence of an elastic element, that is, for the existing version of the baton mechanism [16].



Cam positions

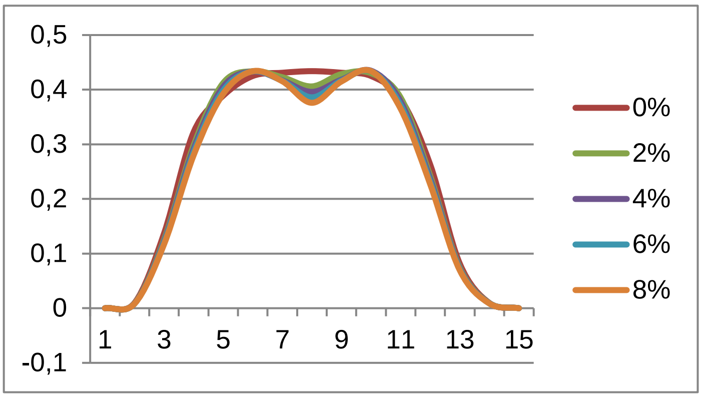
Fig. 3. Angular movements of the rocker arm (reed) of the batan mechanism from the position of rotation of the cam.

Analysis of the graphs in Fig. 4 shows that the lengths r and l significantly affect the amplitude and shape of the rocker oscillations. The amplitude of rocker oscillations is affected by the value of r. So, with a crank radius (minimum radius of the cam profile) of 0.0685 m, the angular movement of the rocker arm reaches 0.34 rad, and with r = 0.0885 m, the angular movement of the rocker arm increases to 0.44 rad [17].

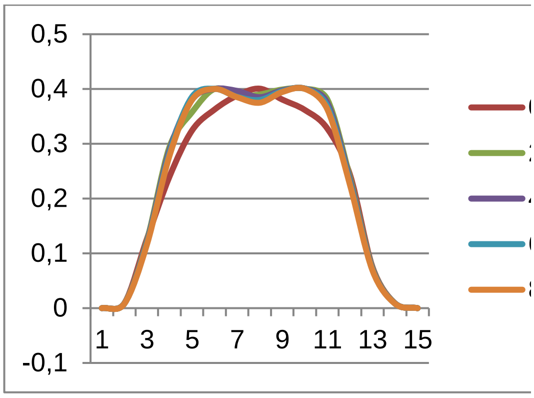
When taking into account the maximum values of deformation of the elastic element in the kinematic pair of the cam between the connecting rod and the rocker arm (in the replacement mechanism), the nature of the angular movement of the rocker arm (rubber reed) changes significantly (Fig. 3).

Based on the processing of the obtained patterns of angular movements of the reed from changes in the maximum deformations of the rubber ring of the cam of the cam mechanism of the weaving loom, graphical dependencies were constructed [18].

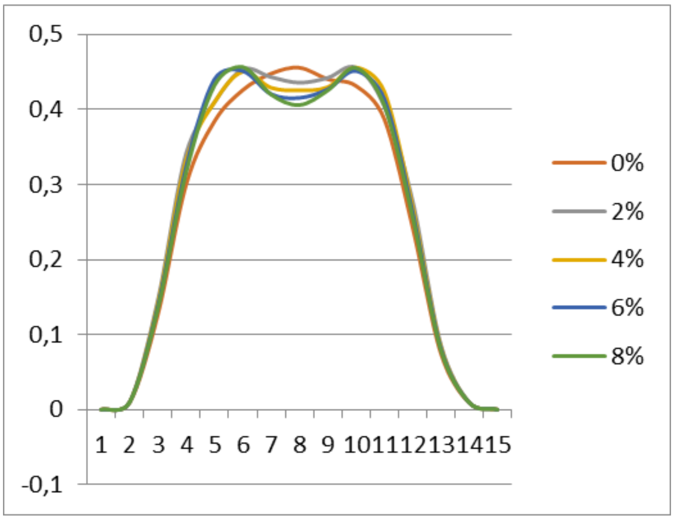
In Fig. 5 Graphical dependences of the change in the swing value of the angular movement of the rocker arm in the surf zone on the change in the deformation values of the rubber ring of the mechanism cam are presented.



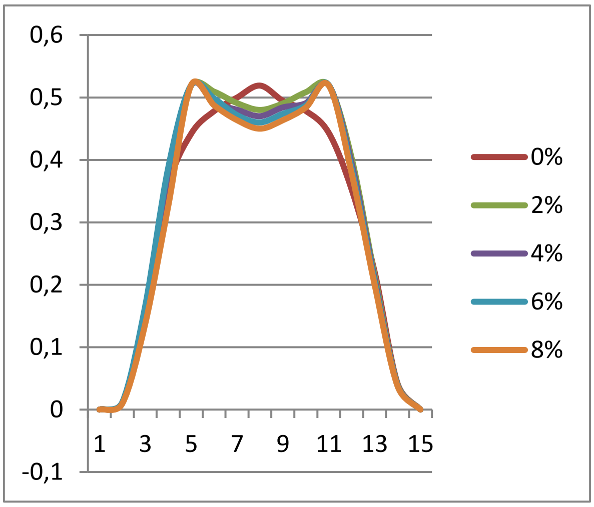
r=0.188, l=0.0785



r=0.188, l=0.0886



r=0.188, l=0.0686



r=0.200, l=0.0785

Fig. 4. Regularities of angular movement of the rocker arm (reed) taking into account the deformation of the elastic element.

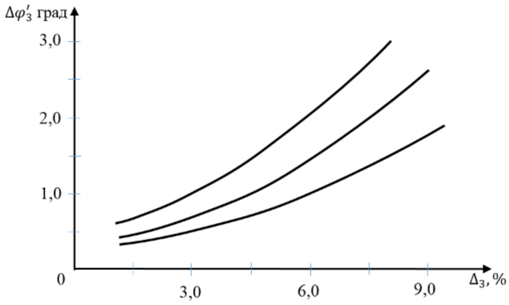


Fig. 5. Graphical dependences of the change in the swing value of the angular movement of the rocker arm in the surf zone on the change in the deformation values of the rubber bushing of the cam mechanism roller [19].

Conclusion. Analysis of the graphs (Fig. 5) shows that with increasing values of deformation of the rubber ring, the range of movement in the extreme position of the rocker arm (in the surf zone) increases according to a nonlinear pattern. In this case, the value $\Delta\varphi_3'$ reaches $3{,}1^0$ at $\Delta_3 = 9{,}0\%$.

To ensure the necessary stay and oscillation of the rocker in this zone $\Delta\varphi_3' \leq (1,0^0 \div 1,5^0)$, the recommended values are $\Delta_3 = (5.5 \div 6{,}5)\%$. This ensures the necessary quality of the fabric forming process in the weaving machine [20].

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