POSSIBILITY TO UTILIZE FIVE OR SIX TURNS IN THE TECHNIQUE OF THE THROW OF THE HAMMER TO INCREASE THE TANGENTIAL VELOCITY OF THE RELEASE.

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Given a set of three axes in which the x-axis is the bisector of the throwing triangle; the origin O the intersection of the x-axis with the outer edge of the throwing circle; the y-axis the tangent to the throwing circle passing through O; the z - axis the vertical in O. The positive direction of x is towards the field; of y towards the left for a thrower with his back to the field, and for z upwards.

I will analyze the throw of a right-handed athlete using the "made in USSR" technique, first used by Y. Sedykh. Observing the hammer from above and projecting its trajectory onto the x-y plane, the hammer is seen to describe a series of ellipses not completed because of the translation and slip produced by the inertia of the hammer-head. The ratio between the diameters and the translation shows that part of the translation and all of the slipping cause many problems and limits the increase of rotational velocity.

Looking at the same throw from a positive point on the y-axis, projecting onto the x-z plane we see that the system (athlete and hammer), particularly when the athlete is on one foot, is rotated in a clockwise direction around y. The moment (T) of the weight of the hammer produces this effect.

Looking more closely at the forces applied by the athlete using this technique, to see how they create the rotation and translation:

- the segment AB connecting the heel of the left-foot with the front of the right foot contains the lever arms of the couple which produces a torque;
- the lengths of the lever arms varies because the axis of rotation is moved towards the left during the rotation.

Study of the individual moments projected onto the x-y plane from above:

- the front of the right-foot applies a force (Fd) through an angle of 90° (measured in the counter clockwise direction from the x-axis) creating the torque (Md) - rotating the system in the counter clockwise direction.

The heel of the left-foot applies a force (Fs) producing a torque (Ms) that also makes the system rotate in a counter clockwise direction until it forms an angle of 0° with the segment AB (passing beyond this angle the moment (Ms) tends to slow the counter clockwise rotation). The right-foot reaches an angle of 90° at the same moment that the left-foot reaches an angle of 150°. The athlete, therefore, translates on his left-foot which is, at this point, the origin of the axis of rotation.

Looking at the system from the x - negative position, we can see the effect of the translation in the y-z plane. The translation produces a clockwise rotation around x. Looking at the same translation in the x-z plane we see a clockwise rotation around y which adds to the torque (T) caused by the weight of the hammer. The summed effect of these rotations can be clearly seen

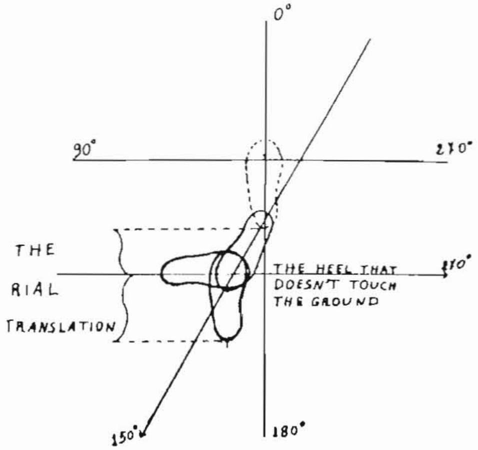

Fig. 1. Translation of the left foot in a rotation of a right-handed athlete by adopting the technique developed in U.S.S.R..The dotted drawing shows the initial position.

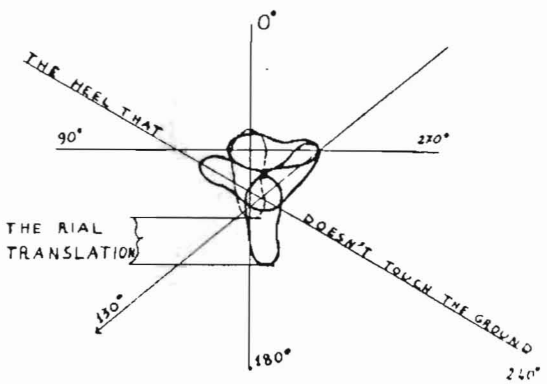

Fig. 2. Translation of the left foot in a rotation of a right-handed athlete by adopting the technique developed by the authors. The dotted drawing shows the initial position.

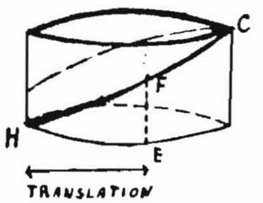

Fig. 3. The cylinder containing the arc of a spiral that rises through 180° and descends through 180°.

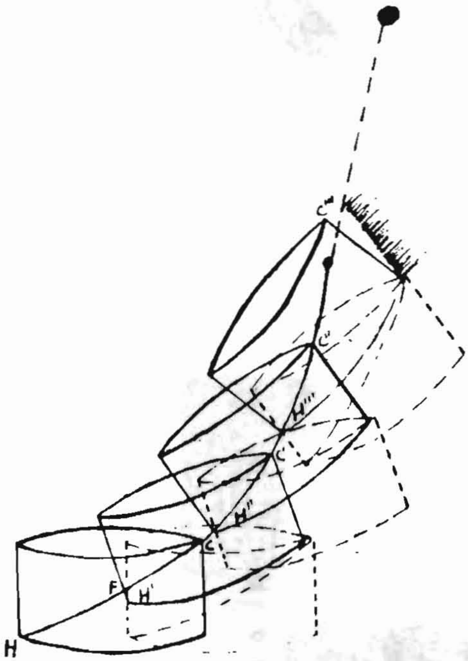

Fig. 4. The polihelical-cylindrical variable angle model.

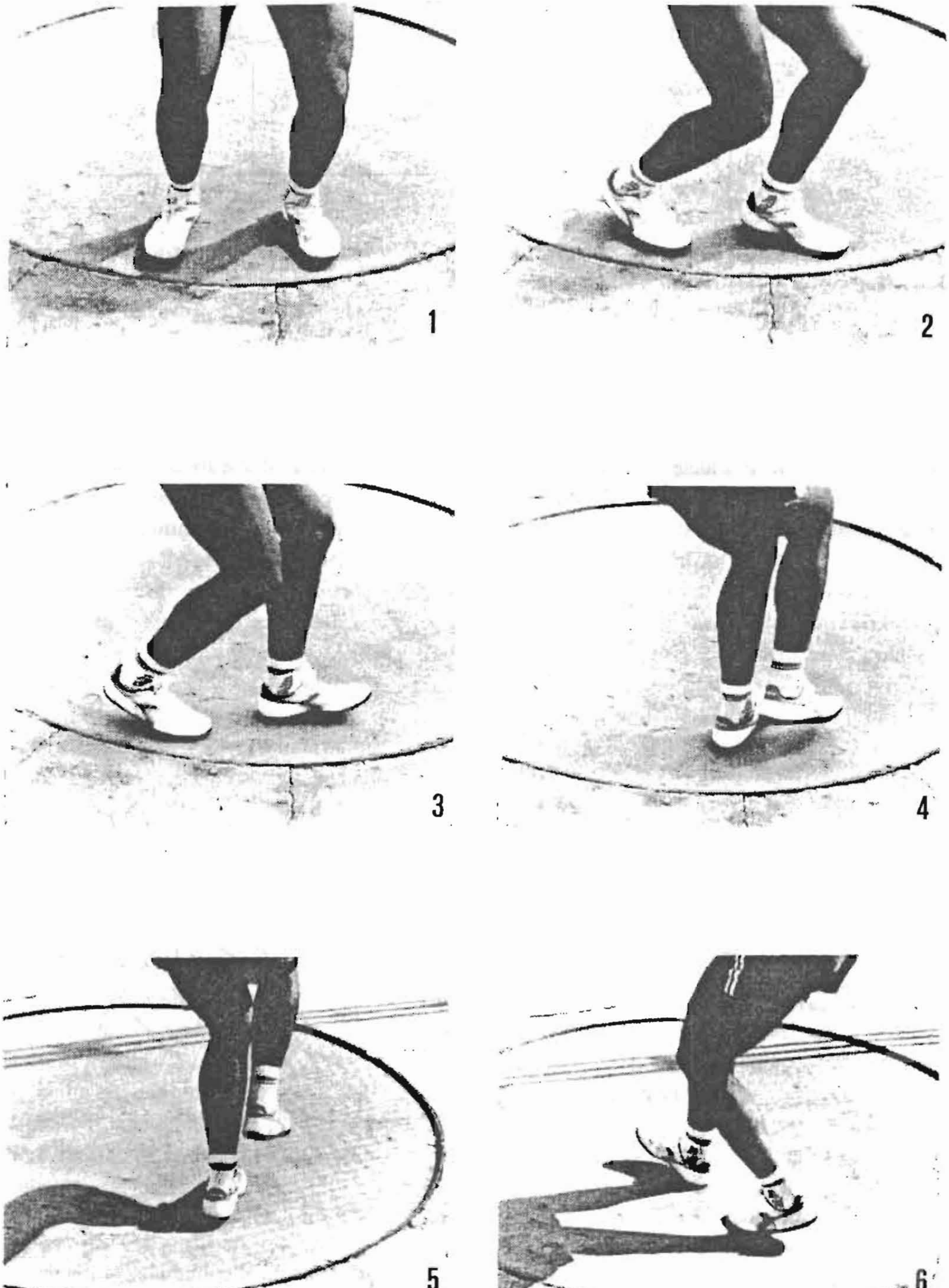

Fig. 5. Photo sequence of the proposed technique.

in the x-y plane. In fact, the axis of rotation of the system has an angular velocity of procession around an axis parallel to z with a radius R.

In the technique which I have developed the front of both feet rotate through an angle of 80° together and then, while the right-foot continues to the 90° position, the left-foot rotates on the heel to 90°. At this point the system translates on the left-foot which, however, continues the heel centred rotation up to 130° - here, its centre of rotation moves to the front of the foot, which then continues to rotate to 240°, when the right-foot again makes contact with the ground. Both feet then rotate together up to 0° from where they can repeat the rotation described.

The rotation, centred on the front of the left-foot from 240° to 0°, allows both feet to assume the best position for the first part of the next rotation on the front of both feet. With this method the moments (Ms) and (Md) produce only counter clockwise rotation in the x-y plane, since the left-foot at no-time rotates more quickly than the right. Furthermore, as the translation on the left-foot occurs when the distance between the two feet is small the rotation around y is minimized. Therefore the sum of this rotation and the moment (T) is much less pronounced than that which is seen with the soviet technique. We also see that the segment AB, between the front of the right foot and the heel of the left, is shorter with the new technique and, therefore, the translation along y is diminished.

The method of toe-heel translation has greatly diminished the space needed to complete a rotation, this allows the athlete to make more rotations in the throwing circle.

A computer programme in Hp-Basic has shown that with my method it should be possible to make 7 complete rotations in the throwing circle; whereas, with the soviet technique the number of rotations possible is, in theory, 4, however these 4 theoretical rotations cannot be carried out. With the new technique the velocity of sliding is so much reduced that the 7 theoretical rotations should result practicable.

Considering the angle of inclination of the rotating hammer, the trajectory projected onto the x-z plane, is represented by a series of segments, (inclined planes seen edge on), the angle of inclination of the first rotation and the last is the same in both methods; since the increase in inclination with each rotation with the new technique is smaller. This has useful consequences for the distribution of energy.

It is possible to compare the two techniques using a geometrical model that can also be made into a mechanical model formed of series of cylinders each containing the arc of a spiral. These spirals rise through 180° and descend through 180°. The cylinders must be able to rotate and translate while a ball runs along a guide made in such a way as to simulate the behaviour of the hammer during the launch using the two techniques. This is necessary as it would be difficult for an athlete to learn and use both techniques with equal ability.
Each cylinder must, therefore, contain the points and segments essential to the execution of the launch.

C is the highest point reached by the hammer; the arc CF is the two footed phase, the arc FC the one footed phase, F is the point at which the one footed phase begins, H the lowest point of each rotation, HE the translation.
I have called this: "The polyhelical-cylindrical, variable angle model".