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SPRING LOCK FOR X-RAY APPARATUS

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2 Sheets-Sheet 1

FIG. 1

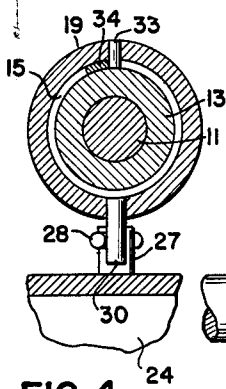
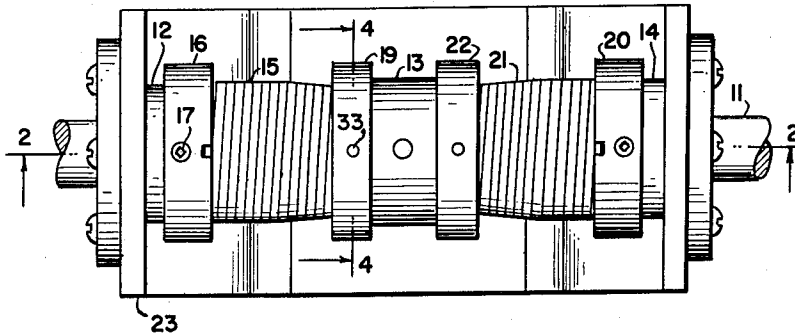


FIG. 2

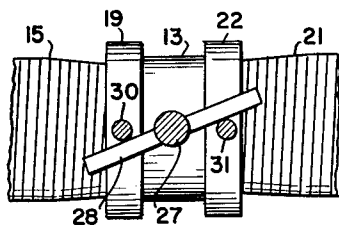
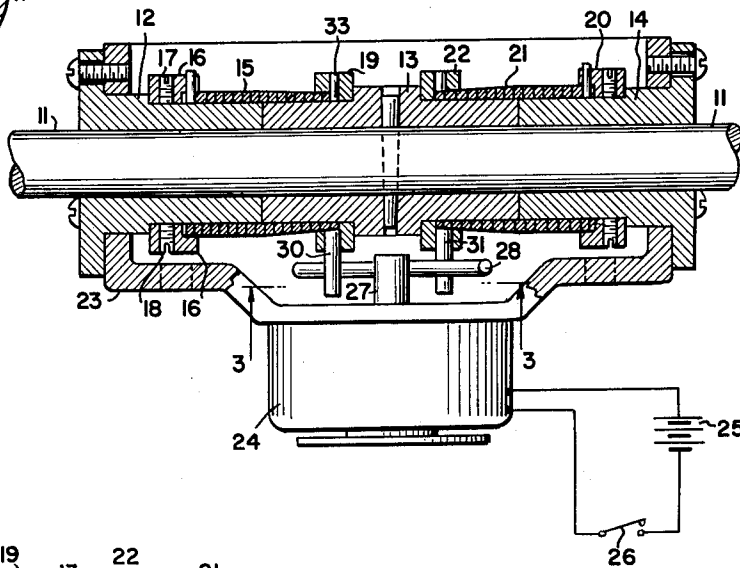


FIG. 3

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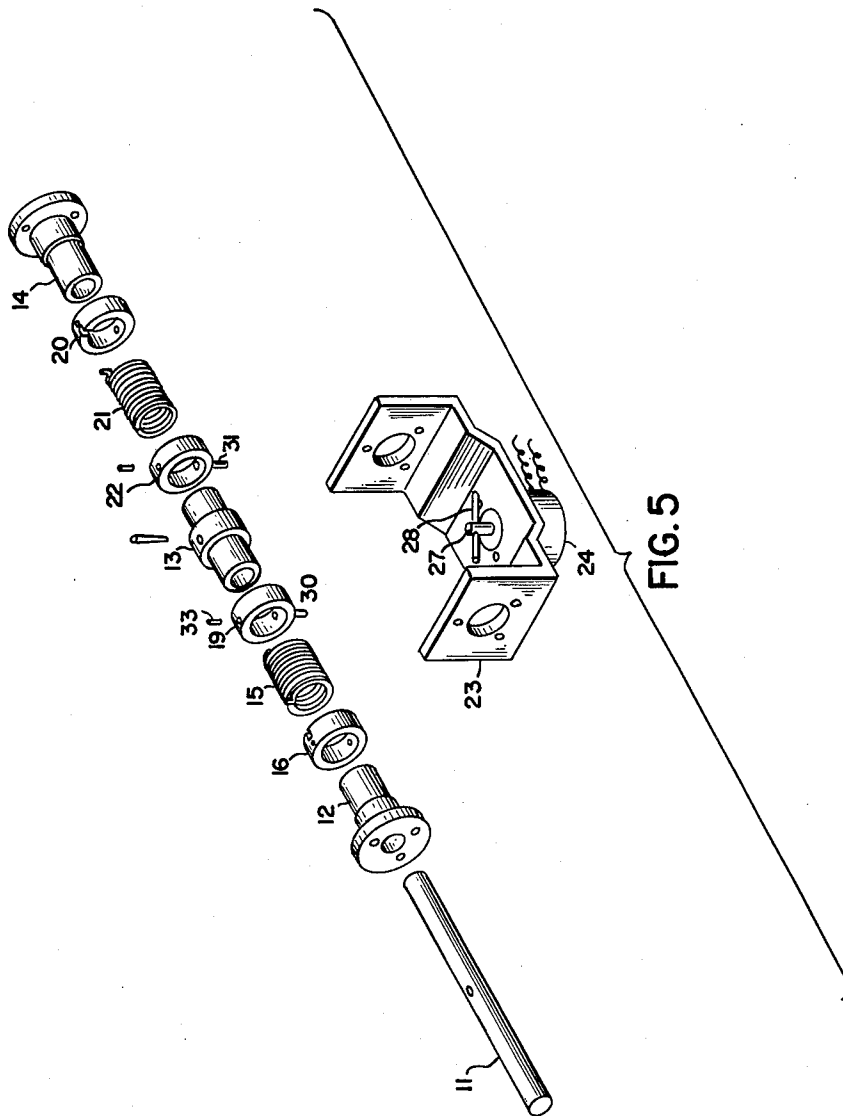


FIG. 5

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SPRING LOCK FOR X-RAY APPARATUS

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3 Claims. (Cl. 188—77)

This invention relates to a spring actuated drive shaft locking device for use in conjunction with X-ray apparatus driven by a bi-directionally rotatable shaft.

In diagnostic medical X-ray technology, the table upon or against which the patient rests, and the apparatus for obtaining the radiograph, must be locked into position during the taking of the radiograph to insure the avoidance of mechanically introduced motion that could blur the radiographic image formed on the spot film. An advanced form of table and related apparatus is disclosed in detail in a copending application entitled "X-ray Apparatus" by Arthur J. Kizaur, Serial No. 764,911, which was filed on October 2, 1958, now United States Patent No. 2,966,588, which issued on December 27, 1960. The table and apparatus in this application has great flexibility by virtue of the table being capable of uninterrupted angulation through 180°, and of lateral movement of great length to facilitate transfer of hospital cart patients and in many instances, eliminating the need for the transfer. The fluoroscopic carriage and screen support has freedom of motion in three dimensions, i.e., in vertical, longitudinal and transverse directions relative to the table. Each one of the three directions of motion for the fluoroscopic carriage and screen support, and for the transverse motion of the table, requires a drive which for certain purposes and at certain times, must be stopped and locked. A drive shaft for each of these motions must be locked to insure the absence of chance movement and vibration when the spot film carrying cassette is shifted into radiographic position.

To properly perform its function, the lock should be structurally simple and positive in its action, and very strong, since the equipment to be locked in position is bulky. To insure that the X-ray exposure may be made immediately upon the placement of the spot film in radiographic position, the lock should operate free of mechanical backlash that may result in undesirable vibrations, and should be actuated as rapidly as possible, i.e., the interval between the flipping of the switch and the completed cessation of movement of the drive shaft in the locked position should be kept to a minimum.

It is desirable in the radiographic art that when the fluoroscopic carriage and screen support are in position and the spot film is shifted to its radiographic position, all of the locks for the carriage and screen support be set automatically. Consequently, the lock utilized should be one adaptable and especially amenable to electrical control, and is preferably an electromagnetically actuated device.

In therapeutic medical X-ray, apparatus, such as a 300 kilovolt therapy unit, is often disposed in a manner producing very high torques, especially since non-linear motion is involved in its operation. Such applications require even stronger and more positive locks than does the diagnostic equipment wherein the motion of the equipment is linear.

Both diagnostic and therapeutic X-ray devices are usually installed and operated in quiet rooms or areas. It is

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highly desirable, from the viewpoint of maintaining the patient's composure, to keep the noise level low and especially to avoid sudden loud noises. The lock used for the equipment should, therefore, be as quiet in operation as possible.

These requirements are satisfied in accordance with the principles of the invention; an embodiment thereof, described below, contemplates a helical spring lock wherein two separate helical springs, having an internal diameter smaller than that of the shaft element which they are to lock, are coaxially mounted upon and wrapped around the shaft. Each spring is also secured to a stationary member, to thereby prevent rotation of the shaft. One end of each of the springs is movable and controlled by a rotary solenoid, such that when the solenoid is actuated, each of the two springs is expanded or unwrapped, thereby permitting rotation of the shaft around which the springs are coaxially wrapped.

Release of the locked shaft is achieved by mounting the springs such that they unwrap in opposite senses from each other; i.e., the motion of the spring end of one spring in a clockwise direction will expand the spring, while motion of the other in a counterclockwise direction will similarly expand it. This arrangement of the two springs insures positive locking action, irrespective of in which of the two angular directions the shaft may be tending to rotate. The solenoid drives the two spring ends, when the solenoid is actuated, in these opposite senses simultaneously.

The helical spring lock structure is exceedingly compact because of a novel coupling mechanism between the rotary solenoid stem or shaft and the actuating ends of the two springs.

The spring lock also has the advantage that what little backlash may exist is of the type that the equipment is restored to its required position by the spring tension itself.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings.

In the drawings:

FIGURE 1 is a plan view, and FIGURE 2 is a longitudinal cross-sectional view of an embodiment of a helical spring lock for X-ray apparatus, in accordance with the principles of the invention, and is shown by way of example merely for purposes of illustration;

FIGURE 3 is a detail of FIGURES 1 and 2 showing the novel coupling between the rotary solenoid and the springs;

FIGURE 4 is a detail of FIGURES 1 and 2 showing the novel coupling between the actuating rings and the springs; and

FIGURE 5 is an exploded view of the device of FIGURES 1, 2, 3 and 4.

Referring to the figures in greater detail, the elements will be set forth from left to right (relative to FIGURES 1 and 2). Commencing at the left, there is a drive shaft 11 which may either be actuated by, or is responsible for actuating, the X-ray apparatus of interest. The drive shaft 11 may be actuated by a source of motive power on the left (not shown). Coaxial with and circumscrib-

ing a portion of shaft 11 is a hollow cylindrical retaining element 12 through which shaft 11 is journaled. Immediately contiguous to, and on the right of, retainer 12 is an annular cylindrical drum 13, also coaxial with and circumscribing the shaft 11. Drum 13 is, however, rigidly secured to shaft 11 by virtue of the tapered pin passing through the drum 13 and the shaft 11 in a direction perpendicular to the longitudinal axis of the shaft, i.e., passing through both the drum and the shaft in a diametral position. Contiguous to the right hand side of the drum 13 is a second hollow cylindrical retaining element 14, through which shaft 11 is journaled.

Circumscribing the abutting ends of retainer 12 and drum 13 is a close-wound helical spring 15 disposed such that half of its length sheaths a part of retainer 12 and the other half sheaths a part of drum 13. Helical spring 15 has a constant internal diameter along its entire length which, under ordinary conditions, and when not mounted on the retainer 12, is smaller than the external diameter of that portion of retainer 12 which it sheaths. Since the external diameter of retainer 12 is the same as that of drum 13 in those regions wherein they are both sheathed by helical spring 15, the same relationship between the internal diameter of the spring 15 and the external diameter of the drum 13 also holds as for the retainer 12.

The external diameter of the spring 15 tapers to a smaller dimension from the plane defined by the abutting ends of retainer 12 and drum 13 to the end of the spring in the region sheathing the drum 13. Circumscribing and coaxial with retainer 12 in the region at the left-hand end of spring 15, is an annular adjusting ring 16 which is rigidly secured to the retainer 12 by set screws 17 and 18. The adjusting ring 16 may be rotated to a new angular position about the retainer 12 by loosening the set screws 17-18, resetting the ring to its new, desired position, and then securing the screws once again. The left-hand tip end of spring 15 is bent upwardly in a direction perpendicular to the longitudinal axis of shaft 11, and rests in a slot in adjusting ring 16, such that the left-hand end of spring 15 is fixedly secured to that point in the adjusting ring.

Circumscribing drum 13 in the region immediately to the right of spring 15 is an annular actuating ring 19 which is free to rotate about the drum 13 (see also FIGURE 4 detail). The right-hand tip end 34 of the spring is in contact with and actuated by, but not secured to, a pin 33 which is secured in a hole formed in the actuating ring 19. As a consequence, rotation of actuating ring 19 in one direction (counterclockwise when viewed from the left) about drum 13 results in the bottom end of pin 33 moving in that direction and forcing the tip end 34 of spring 15 to also move in that direction to thereby cause an expansion of spring 15, while rotation of actuating ring 19 in the opposite direction allows the spring to grip drum 13 since pin 33 is moved out of contact with the tip end 34 of spring 15.

Disposed coaxial to, and in a circumscribing relation about the abutting ends of drum 13 and the retainer 14, are an adjusting ring 20, a helical spring 21 and an actuating ring 22 (from right to left), which occupy the very same relationship relative to the abutting ends of drum 13 and retainer 14 as do the adjusting ring 17, helical spring 15 and actuating ring 19 relative to the abutting ends of retainer 12 and the left-hand end of drum 13. The sole difference in the relationship is the fact the helical springs 15 and 21 are arranged to unwrap in opposite senses, so that a rotation of the actuating rings 19 and 22 in a clockwise sense (when looking at the shaft 11 from the left) results in an expansion of spring 21, and therefore a lessening of the radial force exerted on shaft 11 by the spring, while spring 15 remains in its contracted position, thereby maintaining the radial force exerted on the shaft. Likewise, rotating the actuating rings 19 and 22 in a counterclockwise direction has the opposite effect on the two springs from that which was

obtained by a clockwise rotation. The terms "contract" and "expand" with respect to the helical springs mean nothing more than, in the case of expansion, a tendency for the spring to unwrap about the drum, while "contract" indicates a tendency for the spring to wrap more tightly about the drum 13.

Fixedly secured to an end of each of retainers 12 and 14, is a bracket 23, which extends below the entire structure described above. The function of the bracket 23 is to support a rotary magnetic solenoid 24, which may be actuated by an energy source 25 through a switch 26. Although the switch 26 is shown as a mechanical switch, it may represent a relay contact actuated elsewhere by automatic electrical means.

The solenoid has a rotatable stem 27 aligned with the taper pin securing the drum 13 to shaft 11. Mounted on the stem 27 is a cross pin 28 which is adapted to rotate in a plane parallel to the longitudinal axis of shaft 11 by virtue of the rotation of stem 27 when the solenoid 24 is actuated. The stem 27 is mechanically biased by a small spring at its base (not shown), such that cross pin 28 returns to a position parallel to the axis of shaft 11 when the solenoid 24 is not actuated, i.e., when switch 26 is open. Extending radially from each of actuating rings 19 and 22 are actuating pins 30 and 31; these pins 30-31 are disposed such that rotation of the cross pin 28 in a clockwise direction (when viewing the stem 27 from the bottom of the solenoid 24 as viewed and shown in FIGURE 3) results in the right-hand side of cross pin 28 engaging pin 31 to drive the actuating ring 22 in a clockwise direction (when viewing the shaft 11 from the left), while the left-hand end of cross pin 28 will engage the pin 30 to drive the actuating ring 19 in a counterclockwise direction (also when viewing shaft 11 from the left). The rotary solenoid 24 has internal stops such that stem 27 cannot execute a complete rotation, and therefore cross pin 28 cannot execute a full 360° rotation.

Since springs 15 and 21 are disposed so as to unwrap in opposite senses about the drum 13, the actuation of rings 19 and 22 in opposite senses results in the two springs operating in the same way functionally, i.e., they will both be expanded or will tend to unwrap and therefore to release the drum 13 about which they are mounted. When the solenoid 24 is de-energized as by the opening of switch 26, the springs 15 and 21, by their own torsional force, wind tightly about the surfaces of the drum 13 and the retainers 12 and 14 respectively, so as to create a bearing friction which locks the drum and the shaft against rotation with respect to a fixed structure.

The locking force provided by this embodiment in accordance with the invention, results from the tremendous friction generated through the radial force exerted by the helical springs 15 and 21 (by virtue of their having a smaller internal diameter than the external diameter of drum 13) upon the surface of drum 13. This force is readily diminished by expanding the springs, as is done by the rotation of the actuating rings 19 and 22, to thereby decrease the radial force exerted by the springs. Since the force required to expand the springs 15 and 21 is only a small fraction of the locking force provided by the embodiment, the use of a relatively small solenoid for actuation of the adjusting rings is possible.

The tapering of the springs 15 and 21 is for the purpose of eliminating mechanical backlash in the system. As is well known in the art, the taper speeds up the gripping action when the spring is released, by decreasing the moment of inertia of the spring wire cross-section. The coupling between the actuating ring and the spring, detailed in FIGURE 4, preserves this effect; if the coupling were done by bending the spring tip up into a recess in the actuating ring (which is the common approach and is the way the spring is coupled at its other end to the adjusting ring) then the advantage of the taper in eliminating backlash would be lost.

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Although a tapered spring has been shown, similar advantages may be obtained with two springs, each having coils of uniform thickness but different from each other. The springs may be welded together in tandem so that they may, for example, replace tapered spring 15 (or 21, or both). The spring having the thinner coils would be located in the position of the tapered section of spring 15, while the spring having the thicker coils would be located about the retainer 12 and the joint between retainer 12 and drum 13. In such an arrangement, and also when using a tapered spring, it is important that the bridging coil, i.e., the coil (or coils) located about the joint or interface between retainer 12 and drum 13, be a thick one, since the coil at that region bears the heaviest load.

The magnitude of the locking force is a function of the number of coils in each spring, as well as the relationship of the internal diameter of the helix to the external diameter of the drum about which it is wrapped. Each one of these three constitutes parameters which may be utilized for varying the locking force. In this connection, it may be noted that the adjusting rings 16 and 20 may be reset so as to expand or contract the springs 15 and 21, and thereby control the zero or initial mechanical setting of the springs as required.

The operation of the above described embodiment in accordance with the invention may now be readily understood. In the locked condition, with switch 26 open, the springs 15 and 21 are tightly compressed against their respective retaining members 12 and 14, and the left and right-hand regions of drum 13. As a consequence, a clockwise rotation of the shaft 11 (looking at the shaft from the left) is opposed by frictional forces exerted by spring 15, since a clockwise direction of rotation inherently tends to contract spring 15 even more than its normal condition. A clockwise rotation of the shaft is in a direction which tends to expand rather than contract spring 21. Conversely, a tendency of shaft 11 to rotate in a counterclockwise direction is opposed by spring 21. Actuation of the solenoid through closing the switch 26 results in rotation of the actuating rings 19 and 22, such that they are rotated in opposite angular directions, thereby serving to unwrap or expand both the springs 15 and 21, and thereby removing the radial force exerted by both springs from both ends of drum 13. As long as the switch 26 remains closed, then, the solenoid remains actuated and the cross pin 28 rotated to its stop; and therefore the springs remain expanded and the shaft 21 free to rotate. The moment the solenoid is de-energized by opening switch 26, the cross pin 28 is rotated back to its neutral stop or position by virtue of the above-mentioned biasing spring (not shown), and the springs 15 and 21 once more contract and wrap tightly about their respective portions of drum 13.

The operation of FIGURES 1-4 has been based upon the simultaneous actuation of both the springs 15 and 21 by solenoid 24 to thereby free the shaft 11 for rotation in both angular senses. Certain X-ray applications, however, require that a shaft be free to rotate in one angular sense and be precluded from rotation in the opposite sense. One example is a medical X-ray device wherein a sphere is mounted on a shaft and the sphere is adapted to be pressed against a portion of the patient's torso so as to gently force aside certain internal organs for the purpose of obtaining a less obstructed radiography. This is done by rotating the rack and pinion mounted shaft along the rack in the direction of the patient until the sphere is in place against the body (under some pressure). The shaft must be free to rotate toward the patient, but locked against rotation in the opposite sense. After the radiograph is obtained, the shaft must be free to rotate in the sense against which it was previously locked so as to remove the sphere from its location against the patient's body. Such an arrangement is readily provided in accordance with the principles of the invention. By re-

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moving the cross-pin 28 and solenoid 24, each of the actuating pins 30 and 31 on actuating rings 19 and 22 respectively, may be rotated separately and independently of the other. Rotation of only one of pins 30 and 31 permits rotation of shaft 11 in one, and only one angular sense, since solely one of the springs 15 or 21 is expanded.

While I have shown particular embodiments of my invention, it will be understood that many modifications may be made without departing from the spirit thereof, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim is:

1. A spring lock for use with X-ray apparatus comprising: first and second cylindrical stationary members in axial alignment; a rotatable cylindrical member disposed between said first and second members and in axial alignment therewith; a first helical spring disposed coaxially with and wrapped about a portion of said first stationary member and about a portion of said rotatable member adjacent said first member; a second helical spring disposed coaxial with and wrapped about a portion of said stationary member and about a portion of said rotatable member adjacent said second member; said first, second and rotatable cylindrical members all having the same external diameter; said first and second springs having an internal diameter which when said springs are not mounted upon said first, second and rotatable members is smaller than said external diameter of said first, second and rotatable members; and means in contact with said springs for partially unwrapping said springs in the area of said rotatable member in opposite rotational senses to thereby increase the internal diameters of each of said springs.

2. A spring lock for X-ray apparatus as recited in claim 1, wherein said means for unwrapping said springs includes means for unwrapping said springs simultaneously.

3. A spring lock for use with X-ray apparatus comprising: first, second and third hollow members, each having a cylindrical portion, said three members being axially aligned in tandem relation and having equal external diameters; a cylindrical drive shaft coaxially disposed to said three members with said drive shaft rigidly secured to and through said second member which is intermediate said first and third members, said drive shaft being journaled in said first and third hollow members; a first helical spring normally having an internal diameter smaller than said external diameter of said first, second and third members, said first helical spring being wrapped about a portion of each of said first and second members; a first securing means for securing one end of said first spring to said first member; a first actuating annular ring coaxial with, external to, and rotatable about said second member, said first actuating ring having a pin in contactable but unsecured relation to an end of said first spring opposite to that end secured to said first securing means; a second helical spring normally having an internal diameter smaller than said external diameter of said first, second and third members, said second helical spring being wrapped about a portion of each of said third and second members; a second securing means for securing one end of said second spring to said third member; a second actuating annular ring coaxial with, external to, and rotatable about said second member, said second actuating ring having a pin in contactable but unsecured relation to an end of said second spring opposite to that end secured to said second securing means, said first and second actuating rings each having a radially extending pin emerging from its external surface in the same quadrant of said actuating rings; a rotary solenoid disposed below said second member and having a rotatable stem extending toward said second member in a direction perpendicular to the longi-

tudinal axis of said drive shaft; a cross pin rigidly secured to said stem and mounted thereon in a direction perpendicular to the axis of said stem and to said actuating pins radially extending from said actuating rings and positioned on said stem to contact said actuating pins when said stem is rotated; said first and second members being mounted on a chassis and fixedly secured thereto whereby said second member, said drive shaft, and said actuating rings are all rotatable relative to said first and third members.

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