Oct. 9, 1962 E. JAEGER 3,057,201

ERGOMETER

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Fig. 1

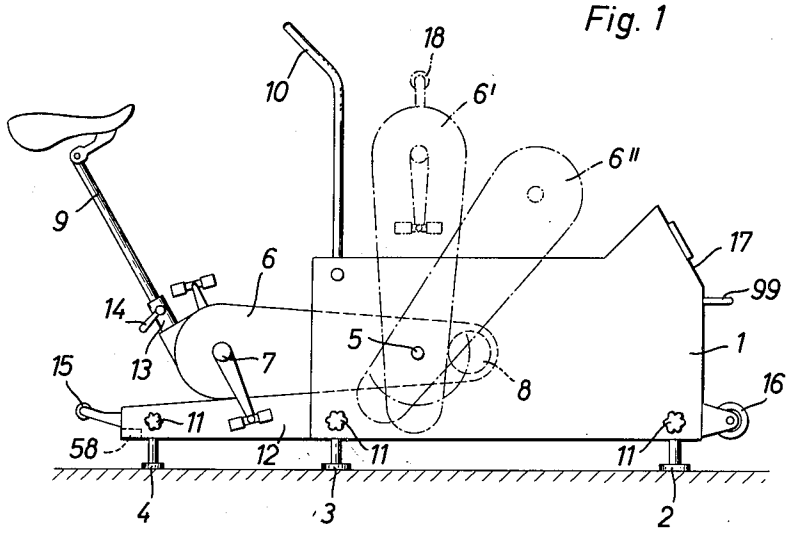


Fig. 2

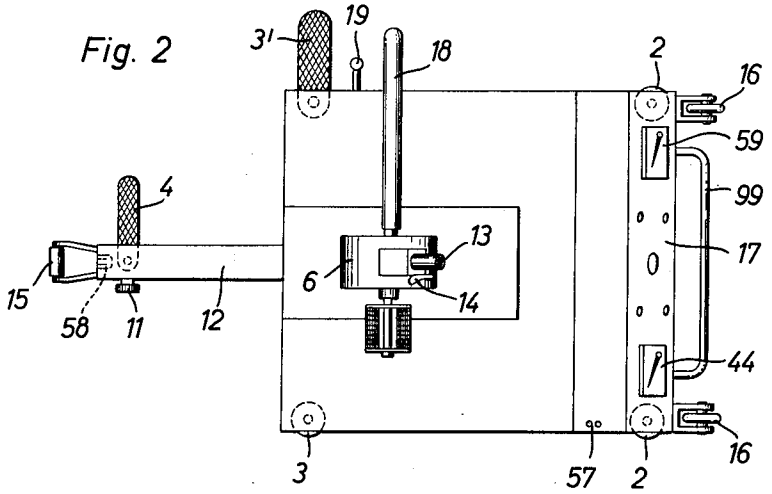


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Fig. 3

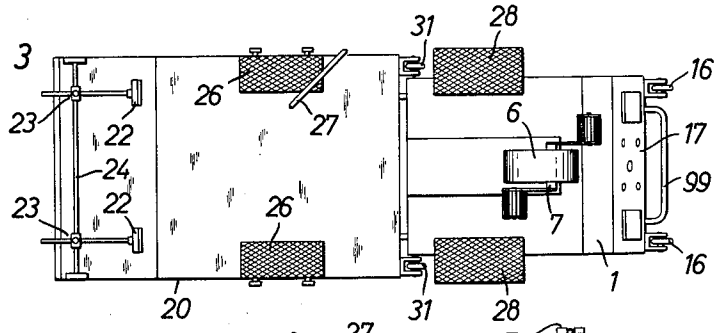


Fig. 4

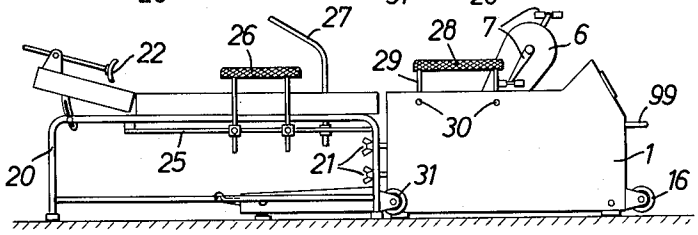


Fig. 5

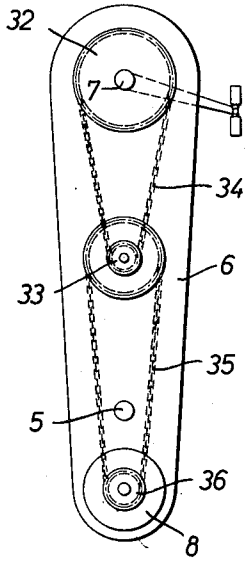


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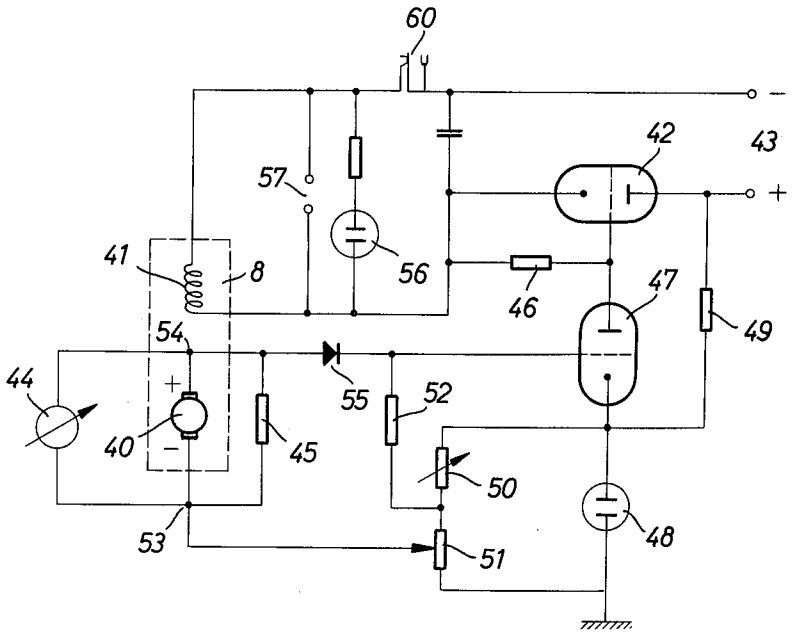
Fig. 6

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3,057,201

# ERGOMETER

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16 Claims. (Cl. 73—379)

The invention relates to an ergometer, that is to say an apparatus which enables a patient who is to be examined to be subjected to a quite specific stress.

For high demands as regards accuracy, a type of ergometer has become generally established, which is known as a "bicycle ergometer." These ergometers comprise pedals and a seat in the manner of a bicycle and the power transmitted to the pedals by the patient can be absorbed directly by friction, although in the majority of known types of ergometer, the mechanical power is converted by means of a dynamo into electric power which is then in turn dissipated by a resistance. The invention only relates to ergometers of the last-mentioned type.

It has been found desirable to construct an ergometer in such a manner that it can be actuated by the patient in the lying, sitting or standing position, in order that the various tests which arise may be carried out with one and the same apparatus. For example, during examinations in which an EKG is taken at the same time, the patient generally has to lie down and this is also necessary when measuring blood pressure in veins, arteries and heart cavities etc., as well as with simultaneous X-ray examinations. Examination while sitting reproduces the energy expended by the patient most accurately because the patient does not have to exert any effort in supporting any limbs which is not shown in the result of the measurement. Measurement while standing has proved suitable for many investigations regarding capacity for work. With all three types of operation, moreover, it is desirable to adapt the apparatus to the size of the patient. The changeover from one mode of operation to the others, as well as the adaptation to the size of the patient, should be able to be carried out rapidly and easily if possible by a single person, that is to say the examining doctor himself. It is also important that the characteristics of the ergometer, that is to say, for example, the internal friction losses, should not vary on changing over from one mode of operation to another. Another important requirement is that the apparatus should be absolutely stable in all operating positions so that it does not wobble or slip even when the patient applies the maximum energy to the instrument.

It is further important that the energy received by the ergometer should be independent of the rotary speed within a certain range because experience has shown that it is very difficult, particularly for elderly or sick people, to maintain the speed constant at a specific value. On the other hand, a measurement of the rotary speed is desirable because the physiological conditions vary somewhat with the rotary speed. The possibility should therefore be provided for the patient to ascertain easily whether he is keeping to the desired speed range.

A large number of ergometers are already known in which some of the said requirements are met in general. For example, an ergometer is known which works with an eddy-current brake so that the energy is independent of the speed within a certain speed range. The apparatus can be turned through 90° so that it rests on the ground with another wall and can then be actuated in the standing position. Its stability, however, is then no longer very satisfactory. This apparatus is unsuitable for tests in the prone position. Nevertheless, it has a continuous energy adjustment and a freewheel introduced between the eddy-current generator and pedals. A serious disadvantage of this ergometer consists, inter alia, in that it is very heavy and that the eddy-current generator contains large inert masses so that the slowing-down time amounts to about 10 minutes. As a result, the measurements may be falsified, of course, because the power produced by the patient may be falsified during the measuring period by the energy of rotation stored up in the flywheel mass.



In addition, an ergometer is known which permits examination in the prone, sitting and standing positions. Again it consists of a construction resembling a bicycle with pedals, saddle and a kind of handlebar for holding; during examination in the prone position, the apparatus is simply turned through 90°, and placed on a bed, in which case the base has to rest against a wall. Lifting the relatively heavy apparatus is not very easy and in addition damage to the bed and the wall may easily occur. For examination in the standing position, the apparatus is placed on a stand, which requires at least two people. In addition, there is no means for adjustment in height so that the working conditions are unfavorable for large and small patients.

Furthermore, an ergometer is known on which a table is mounted so that it is particularly suitable for examination in the prone position.

Finally, a bicycle ergometer is known which, although it is only constructed for examinations in the sitting position, nevertheless uses an electronic regulating device for maintaining the output energy constant at varying speeds of rotation. The energy can only be adjusted step-by-step. The regulating means acts on the field winding of a direct-current generator with separate excitation.

It is the object of the invention to provide an ergometer which meets all the requirements mentioned above, that is to say, which is suitable for examinations in the prone, sitting and standing positions, which stands absolutely safe and steady during all modes of operation and which can be changed over from one mode of operation to the others by one person without trouble. Furthermore, the output should be independent of speed within a certain range and it should be easily possible for the patient to supervise the correct mode of operation.

The ergometer according to the invention is characterised in that the pedals, transmission mechanism and loading generator are combined to form a unit which contains the control panel and electronic device in a stationary box and is mounted for pivoting as a whole about an axis. A locking device is preferably provided, which enables the pivotable unit to be held in three positions. The stationary box is preferably provided with extending legs so that it can be adjusted in height.

The invention will now be described in more detail with reference to a constructional example, other features also being disclosed which are desirable or convenient for meeting the above-mentioned requirements. In the drawings:

FIGURE 1 is a side view of the ergometer according to the invention for the examination of seated patients;

FIGURE 2 is the ergometer of FIGURE 1 seen from above but after conversion for the examination of a standing patient;

FIGURES 3 and 4 are views from above and the side of the ergometer according to the invention for the examination of a prone patient;

FIGURE 5 is a view of the unit which is pivotable as a whole and which comprises pedals, transmission and generator and,

FIGURE 6 is a circuit diagram for the electronic device which can be used in conjunction with the ergometer as shown in FIGURES 1 and 5.

FIGURE 1 illustrates diagrammatically a constructional example of the ergometer according to the inven-

tion. It consists essentially of a housing 1 which rests on the ground with the feet 2, 3 and 4. Mounted in the housing for pivoting about a shaft 5 is a unit 6 which comprises pedals 7, a transmission mechanism, not illustrated in FIGURE 1, and a dynamo 8 which is indicated diagrammatically. When the unit 6 is in the position shown in full lines in FIGURE 1 with the saddle 9 and handle 10 inserted, the apparatus serves for examinations in the sitting position. The unit 6 may, however, also be brought into a vertical position 6' and a position 6'' inclined somewhat towards the front of the apparatus, as will be explained in more detail below.

The feet 2, 3 and 4 are adjustable in height and can be located by means of locking screws 11. During examinations in the sitting position, the feet are generally retracted completely and are only shown extended somewhat in FIGURE 1 for the sake of clarity. The adjustable feet may, however, also serve to compensate for irregularities in the floor in order to ensure that the apparatus stands absolutely steady even in this case.

Mounted on the box 1 is an arm 12 on which the unit 6 rests in the lowered position. In order to improve the support, a projection, which is not illustrated in the drawing, may be provided on the unit 6 to rest in a corresponding depression in the arm 12. Furthermore, the unit 6 carries a holder 13 for the saddle 9 which is provided with a suitable clamping device 14 by means of which the saddle may be adjusted in height or removed entirely. A handle 15 is provided at the end of the arm 12.

On its front wall, the box 1 carries two wheels 16 which are arranged in known manner so that they are raised from the ground when the apparatus is in its normal position but permit easy running of the apparatus when the device is tilted, for example by raising the arm 15. At the front of the apparatus there is also provided a front plate 17 which carries the operating knobs and measuring instruments and which will be discussed in more detail hereinafter in connection with the electrical device.

In FIGURE 2, the ergometer is illustrated from above in a position which is suitable for the examination of a standing patient. The saddle 9 and the handle 10 have been removed and one pedal has been replaced by a suitable crank handle 18. In order to ensure that the apparatus stands securely, the foot 4 situated on the arm and the foot 3' on the same side as the handle 18 are elongated in construction. During examinations in the standing position, the feet are brought into the position shown in FIGURE 2, so that the patient can stand with his right foot on the foot 4 of the apparatus and with his left foot on the foot 3' while he actuates the crank handle 18. This ensures that the patient cannot pull the apparatus over even when exerting the maximum energy. During examinations in the sitting or prone positions, the elongated feet 4 and 3' may be turned through 90° so that they no longer project beyond the apparatus and get in the way.

The adjustment of the unit 6 and its locking is effected by means of a lever 19 which serves to actuate any suitable locking device known to engineers versed in this art.

In FIGURES 3 and 4, the ergometer according to the invention is adapted for the examination of a prone patient. The box 1 is firmly connected to a table 20 which may be effected, for example, by screwing by means of wing nuts 21. The unit 6 is in the position indicated at 6'' in FIGURE 1. The table 20 is provided at its head with shoulder supports 22, the position of which can be varied in the longitudinal direction and transversely of the table by means of suitable crosspieces 23 which are secured to a crossbar 24. The table also comprises attachment bars 25 at both sides to which various auxiliary devices, for example an armrest 26 or a stand 27, can be clamped. During examination in the prone position, two leg rests 28, on which the patient can rest his legs when he is not actuating the ergometer, are preferably also mounted on the box 1 of the ergometer. The leg rests 28 rest on supporting bars 29 which slide in corresponding bores in the housing 1 and can be located by means of set screws 30. In this manner, the leg rests may also be adjusted in height.

The table 20 is preferably somewhat wider than the box 1 of the ergometer so that it can easily be brought up to the ergometer on its wheels 31. The table 20 can then also be placed right over the box 1 so that the apparatus can be packed and dispatched with the minimum space requirements.

FIGURE 5 represents somewhat diagrammatically the interior of the unit 6. Connected to the shaft carrying the pedals is a sprocket wheel 32 such as is used in bicycles. In order to reach the rotary speed necessary for driving the dynamo 8, an intermediate shaft 33 is interposed between the shaft 7 carrying the pedals and the dynamo 8. The intermediate shaft 33 carries a small sprocket wheel which is connected, through a first chain 34, to the large sprocket wheel on the pedal shaft, and a large sprocket wheel which, through a second chain 35, drives a small sprocket wheel 36 mounted on the dynamo shaft. The shaft 33 is preferably provided with a freewheel hub so that the inertia of the dynamo cannot react on the patient.

As already mentioned, the whole unit 6 is constructed in the form of a rigid unit and encased by a housing. The unit 6 can be pivoted about the shaft 5 mounted in the box 1 and locked in relation to the housing 1. The centre of gravity of the whole arrangement is selected in such a manner that, seen as in FIGURE 5, it lies somewhat above the pivoted axis 5 so that the unit 6 remains lying in the lowered position illustrated in full lines in FIGURE 1. The unit should, however, be balanced in such a manner that it is possible to raise the unit from the position 6 into the position 6' or 6'' without difficulty. Since the dynamo 8 acts as a counterweight, this is easily achieved.

The adjustment of the height of the apparatus during the examination of a standing patient can easily be effected by raising the apparatus at the rear by the handle 15. As a result, the feet 3 are raised from the ground and can be extended without difficulty and locked again in the extended position. The apparatus is now raised at the front by means of the handle 99 as a result of which the feet 2 are raised from the ground and can likewise be extended and locked. In this manner, an adjustment of the height of the device is possible without difficulty. When the floor is uneven, the locking screws 11 are simply undone so that the feet adapt themselves to the irregularities in the floor. If the screws 11 are now tightened again, the apparatus now stands firmly even on an uneven floor without wobbling.

FIGURE 6 illustrates a circuit arrangement which is preferably used in conjunction with the mechanical part of the ergometer described above.

The direct-current dynamo 8 comprises an armature 40 and a field winding 41 on the stator. The field winding is connected in series with an electronic valve 42 which is fed from a suitable source of direct-current voltage source 43. The armature 40 is connected in parallel with a load resistor 45 and a measuring instrument 44, which indicates the armature voltage. The grid of the valve 42, by means of which the field current is controlled, is connected through a grid resistance 46 to the cathode and at the same time to the anode of a control valve 47. The cathode of the control valve 47 is earthed through a gas-discharge tube 48. In order to maintain the necessary wattless current through the tube 48, a suitable dimensioned resistor 49 is connected between the cathode of the valve 47 and the positive pole of the voltage source 43. Connected in parallel to the glow-discharge tube 48 is a voltage divider which consists of the variable resistor 50 and a potentiometer 51. The con-

necting point between the resistor **50** and the potentiometer **51** is connected through a resistor **52** to the grid of the valve **47**. The slider of the potentiometer **51** is connected to the one pole **53** of the armature **40** and the other pole **54** of the armature **40** is connected through a diode **55** to the grid of the valve **47**. Connected in parallel to the field winding **41** is an indicator lamp **56**, connected in series with a series resistor, and a pair of connector sockets **57**.

The circuit is dimensioned in such a manner that at first a relatively heavy current flows through the valve **42** and hence through the field winding **41**. If the armature **40** now begins to turn, a voltage is induced which appears at the terminals **53** and **54**. This voltage is added to the voltage tapped at the potentiometer **51** and at a specific value, the bias voltage of the diode **54** determined by the voltage divider is overcome and the diode becomes conducting as a result of which the grid of the valve **47** becomes more positive. As a result, the valve **47** begins to conduct current, its anode becomes more negative as does also the grid of the valve **42**. In consequence, the field current is reduced and hence the field induced in the stator of the motor. As the field decreases, however, the voltage induced in the armature **40** is also reduced. The circuit therefore causes the armature voltage to be maintained constant as is also the power converted into heat in the load resistor **45**. Since the load resistance is constant, the voltmeter **44** may be calibrated directly in energy. The height of the armature voltage which is regulated by the stabilizing circuit and maintained constant, can be adjusted by means of the potentiometer **51**. The operating knob for this potentiometer is situated on the front plate **17** and serves for the infinitely variable adjustment of the energy to be supplied by the patient.

In order to allow the regulation to take effect, a certain minimum speed is necessary for the armature **40**. Actually, the speed must be at least so high that, with a maximum field current in the armature, so much voltage is induced that a current, however small, flows through the diode **55**. This speed is dependent to some extent on the energy which has to be supplied by the patient and is set at the potentiometer **51**. In order to render convenient supervision possible for the doctor and the patient, an indicator lamp **56** is connected in parallel to the field winding **41** which in this case is of high-ohmic construction. With a maximum field current, that is to say when the regulation has not yet come into action, the voltage drop at the field **41** is relatively large and the glow lamp **56** burns. If the regulation comes into action, the field current is reduced somewhat. By suitable dimensioning of the field resistance, or by a suitable selection of the glow lamp or by using a voltage divider, it is possible to ensure that the glow lamp is extinguished precisely at the moment when a current begins to flow through the diode **55**, that is to say when the regulation comes into action. It is therefore only necessary to require of the patient that he should pedal so fast that the glow lamp does not light up. This is naturally easier to supervise than observing an indicator on a speed indicator or the like. The glow lamp **56** is preferably mounted on the control panel **17** so that it can easily be observed by the examining doctor. For the patient, a second glow lamp is provided, the lamp-holder of which is provided with a clamping device and can be connected by means of a suitably long cable to two sockets **57**. The clamping device may be clamped at a suitable point on the apparatus depending on the position of the patient so that the glow lamp is always within the field of vision of the patient. During examination in the sitting position, for example, the glow lamp may be clamped to the handle **10**, during examination in the prone position, to the stand **27** and during examination in the standing position to the clamp handle **14** which is raised with the unit **6**.

The glow lamp may, of course, also be connected between the anode and cathode of the valve **42**, in which case the circuit is dimensioned in such a manner that the glow lamp lights up at the desired speed range and is extinguished on dropping below the minimum speed.

The connecting socket **58** for the mains cable is preferably accommodated at the end of the arm **12** which is constructed in the form of a U-rail.

Mounted on the operating panel **17** are the output meter **44**, a speedometer **59** fed by a suitable tachometer generator, as well as a mains switch and the usual indicator lamps, including the glow lamp **56**. In addition, a connecting socket **57** is provided for the connection of the glow lamp to be observed by the patient to supervise the minimum speed and a socket **60** (FIGURE 6) for the connection of a push-button switch. By means of this push-button switch, the examining doctor can switch the load on and off as desired.

What I claim is:

1. In an ergometer, the combination which comprises: a support; a unit which includes a carrier, a dynamo and a work input device, the latter incorporating a transmission interconnecting said work input device with said dynamo, said dynamo and said work input device being mounted on said carrier so that they will always maintain the same relationship relative to each other; and mounting means for mounting said carrier on said support for movement relative thereto between a plurality of different operative positions in which a person occupying different positions, respectively, can operate said work input device, whereby said dynamo and said work input device will always be in the same position relative to each other irrespective of the particular operative position of said unit.

2. The combination defined in claim 1, further comprising electrical indicating means on said support and electrically connected with said dynamo for indicating the work done at said work input device.

3. The combination defined in claim 2, wherein said indicating means are substantially independent of the rotational speed of said dynamo after the same attains a predetermined minimum rotational speed.

4. The combination defined in claim 2, wherein said mounting means mount said unit on said support for pivotal movement relative thereto.

5. The combination defined in claim 2, wherein one of the operative positions of said unit is one in which said work input device can be operated by a person in a lying position.

6. The combination defined in claim 2, wherein one of the operative positions of said unit is one in which said work input device can be operated by a person in a standing or sitting position.

7. The combination defined in claim 2, wherein said work input device comprises pedal means for use when said unit is in an operative position in which said work input device can be operated by a person in a lying position, as well as manually graspable cranking means for use when said unit is in an operative position in which said work input device can be operated by a person in a standing or sitting position.

8. The combination defined in claim 2, wherein said support is equipped with feet which are adjustable in height.

9. The combination defined in claim 8, wherein said support is equipped at its front with rollers, said rollers being spaced from the ground when said support stands on said feet.

10. The combination defined in claim 2, wherein said support is equipped with a rearwardly extending arm adapted to support a seat for a person who is to operate said work input device.

11. The combination defined in claim 2, wherein said support is equipped with means upon which may stand a person who is to operate said work input device.

12. The combination defined in claim 2, further in-

cluding a table adapted to be affixed to the rear of said support.

13. The combination defined in claim 3, wherein said dynamo has an armature and a field winding, and wherein said indicating means include a regulating device which is connected to said armature and which controls the current through said field winding for maintaining the output voltage of said dynamo constant.

14. The combination defined in claim 13, wherein said indicating means comprise an indicator lamp connected in parallel with said field winding of said dynamo for indicating when said dynamo rotates below said predetermined minimum rotational speed.

15. The combination defined in claim 14, wherein said indicating means comprise means for connecting an additional indicator lamp in parallel with said field winding of said dynamo, said additional indicator lamp being



in the field of vision of the person operating said work input device.

16. The combination defined in claim 2, wherein said indicating means are located at the front of said support.

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