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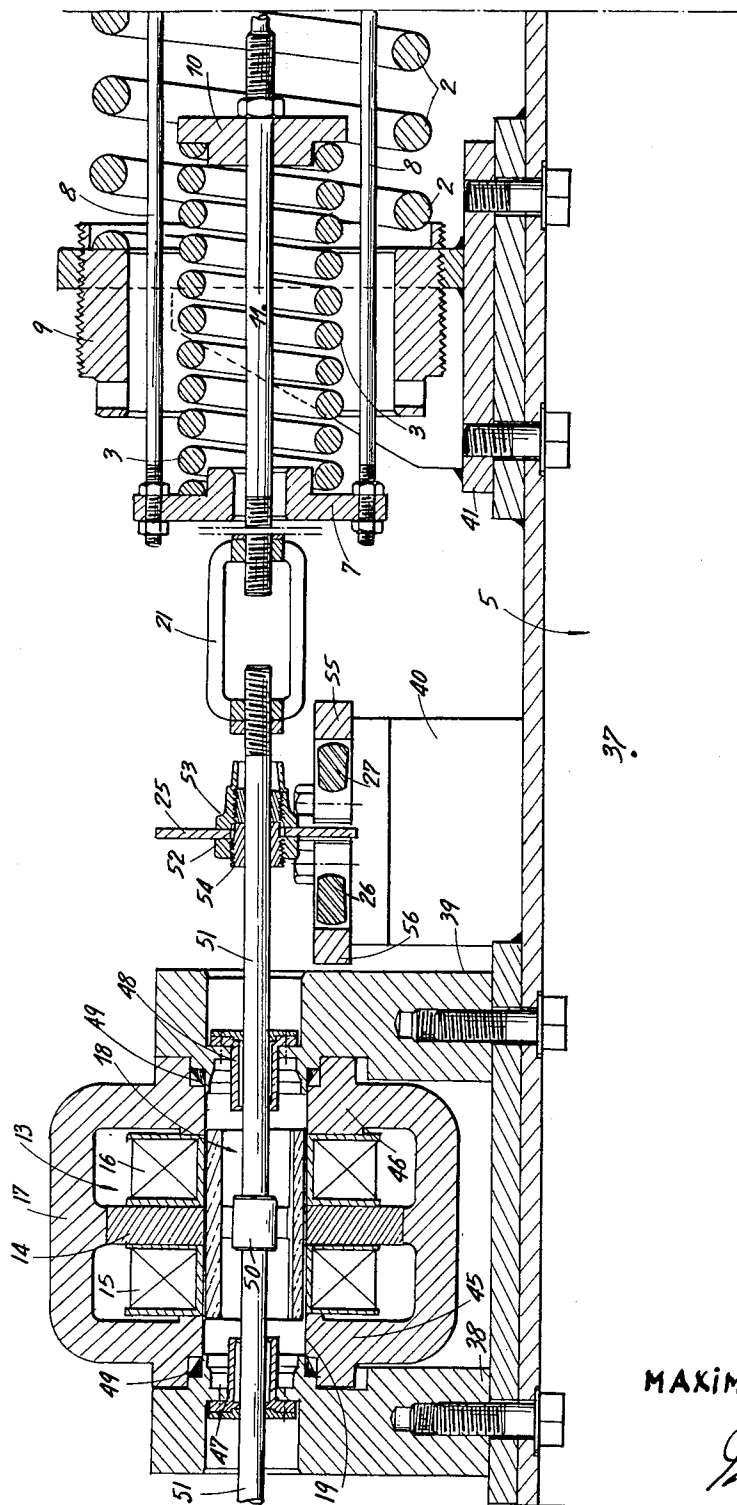
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DEVICE FOR CARRYING OUT ENDURANCE TESTS ON VARIOUS TEST-PIECES

Filed March 18, 1963

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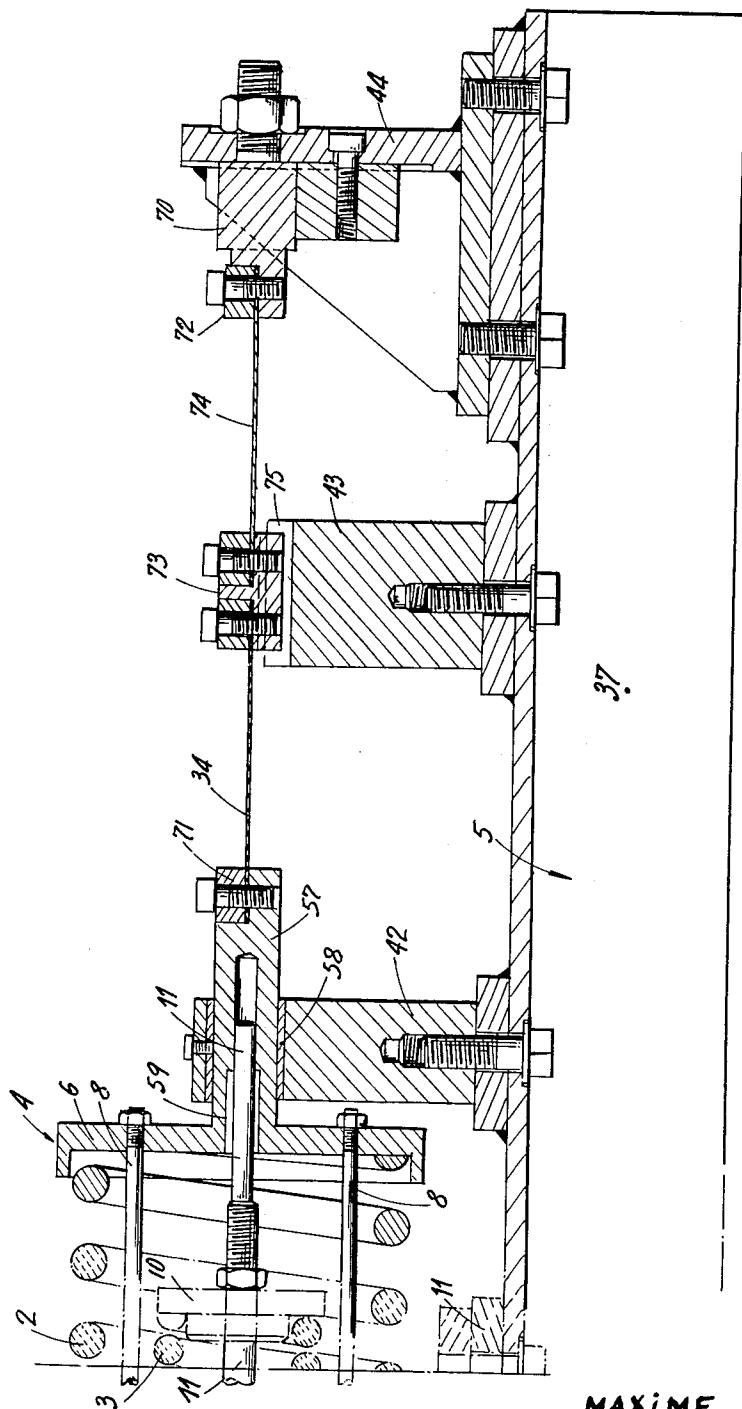


Fig. 4

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Fig.5.

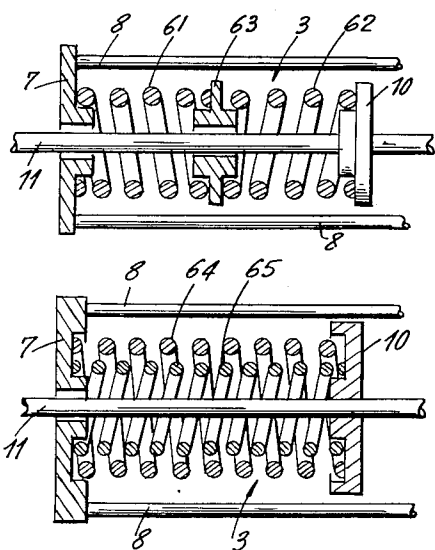


Fig.6.

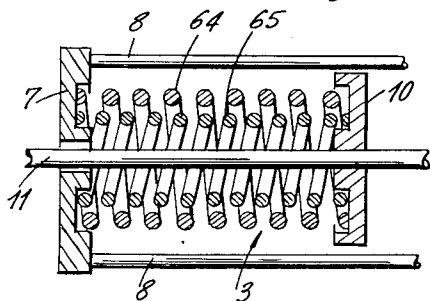


Fig.7.

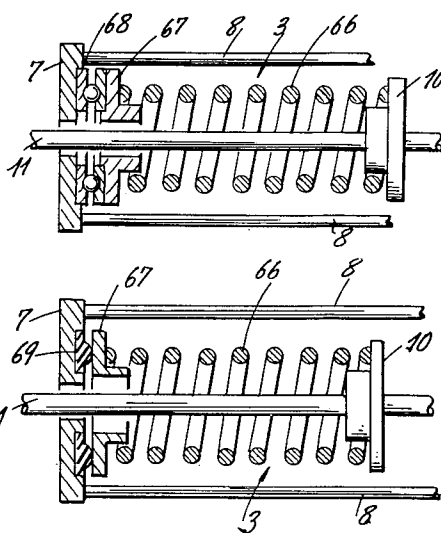


Fig.8.

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DEVICE FOR CARRYING OUT ENDURANCE TESTS ON VARIOUS TEST-PIECES

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9 Claims. (Cl. 73-92)

Endurance tests have the object of ascertaining the behaviour of test-pieces, parts or units, when they are subjected to periodic stresses similar to those produced in actual practice.

Actually, experience has shown that if the amplitude and number of periodic stresses are sufficient, they result in breaking, called "fatigue," characterized in that it occurs abruptly, practically without any warning distortion, and in that the break generally shows two areas: a smooth area and a tearing area.

The present invention relates to a device for carrying out endurance tests on various test-pieces, a method and device which are very simple in conception and very easy to operate.

According to the method of the invention, there is made to coact on the test-piece, on the one hand, at least one adjustable tension elastic element, interposed between said test-piece and a displaceable bearing point, then, on the other hand, at least one second dynamic action elastic component electro-magnetically operated and maintained in a vibratory movement of controlled frequency and amplitude, so that the tension of said second elastic component is periodically variable between given adjustable limits, corresponding to the maximum and minimum elongation that are imparted to it, for producing on the test-pieces periodic stresses algebraically added to the static stress of the elastic element.

In accordance with the invention, the device comprises two dynamic action elastic components, mounted in opposition and of which one of their ends is connected, by a linking component, to a mobile unit cooperating with the fixed part of an electromagnetic circuit, the other end of at least one of said elastic components abutting against a support guided in a fixed frame according to the direction of the stresses to which the test-piece must be subjected which is anchored in this frame and is subject, by means of the support considered as fixed, to distortions close to said test-piece, to the algebraically combined actions of said dynamic action elastic component and at least one static action elastic component bearing on the frame.

Various other characteristics of the invention will moreover be revealed by the detailed description which follows.

Forms of embodiment of the object of the invention are shown, by way of non-restrictive examples, in the attached drawings.

FIGURES 1 and 2 are diagrammatic views of two forms of embodiment of the device according to the invention.

FIGURES 3 and 4 are complementary elevation-sections showing the second form of embodiment in detail, on a larger scale.

FIGURES 5 to 8 are partial sections showing alternatives of a constitutive element of the device.

FIGURE 9 is an analytical diagram showing the method of actuating this device in running a test.

FIGURES 10 to 15 are diagrams showing characteristic types of tests for endurance in pull and/or compression.

According to the method of the invention, it is planned to exert on at least one test-piece 1, two forces F_s and F_d algebraically added to each other. The force F_s is applied

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to said test-piece by an elastic element 2 and the force F_d by an elastic component 3.

A first form of embodiment of the device is shown in FIGURE 1 for operating this method. The two elastic components 2, 3 abut against a support 4, guided in a frame 5 according to the direction of the stresses to which the test-piece 1 is to be subjected, i.e., in translation for the example shown, in which the test-piece is to be subjected to a pull and/or compression test. Practically, the support 4 may be considered as being almost unaffected by the distortions which, in a general way, are very slight. This support is formed by two side-plates 6, 7, rigidly connected by means of tie-rods 8.

The elastic element 2 bears on a threaded ring 9, screwed into the frame 5 to enable the regulating of the initial tension of this elastic element, and hence, of the constant force F_s applied by the latter to the test-piece 1.

The elastic component 3 bears on a plate 10 integral with a rod 11 guided in bearings formed by the side-plates 6, 7 of the support 4.

The plate 10 is electro-magnetically operated and maintained in a vibratory movement of controlled frequency and amplitude, so that the pull of this elastic component 3 is periodically variable between given limits, corresponding to the maximum and minimum elongation which are imparted to it in order to apply to the test-piece 1 the periodical force F_d . To this end, the rod 11 is connected to the mobile unit 12 of an electro-magnetic circuit 13.

In the example shown as non-restrictive, the fixed part of this electro-magnetic circuit comprises as annular permanent magnet 14 with radial field inserted between two energizing coils 15, 16 embedded in an armature 17 fixed to the frame. The mobile unit 12 is formed by a shuttle 18 guided linearly and along its axis, in an annular channel 19 confined by the fixed part of the circuit 13. The energizing coils 15, 16 are supplied with alternating current for creating, in cooperation with the annular magnet 14, a periodic electro-magnetic field causing, by applying the law of minimum flux, the driving of the shuttle 18 in a rectilinear vibratory movement of appreciably constant amplitude. As is well known, the amplitude of the vibratory movement is function of the alternating current voltage supplying the coils 15, 16, so that by regulating this voltage, we ascertain accurately the periodic distortion of the elastic component 3, and hence, the variation of the force F_d that the latter exerts on the test-piece 1.

The mean value of this force F_d must be adjustable. It corresponds to the initial tension of the elastic component 3 in the balanced position shown, in which the shuttle 18 is situated in a median position facing the fixed part of the electro-magnetic circuit 13. For regulating said initial tension of the elastic component 3, provision is made, for example, to connect the rod 11 to another rod 20 integral with the shuttle 18, by means of a turn-buckle 21 tapped with threads of opposite direction.

It is essential that the forces acting on the shuttle 18, of electro-magnetic and elastic origin, should be balanced at every moment, and to this end, another elastic component 22 whose stiffness is equal to that of the elastic component 3 is mounted in opposition to the latter. It is inserted between a plate 23 integral with the rod 20 and a threaded ring 24, screwed into the frame 5 to enable the regulating of the initial tension of said elastic component 22, in alignment with that of the elastic component 3.

It will be noticed that the vibratory movement of the oscillating assembly, formed more particularly by the shuttle 18 and the elastic components 3, 22, cannot be influenced by the elastic element 2, seeing that the support 4 is practically motionless, and hence, that the elastic component 3 can act in cooperation with the elastic ele-

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ment 2 on the test-piece 1, but that the element 2 cannot react on the component 3.

Moreover, the natural frequency of this oscillating assembly must be slightly different from the frequency of the supply current of the electro-magnetic circuit 13. To align the natural frequency to what it should be, an additional inertia mass 25, added to that of said oscillating assembly, is secured on the rod 20. It corrects the aggregate stiffness of the elastic components 3, 22, which, moreover, determines the selection of the latter.

The amplitude of the oscillating assembly must be stabilized with accuracy for it determines, as explained in the foregoing, the variation of the force F_d . For this purpose, there is first provided, the regulating of the natural frequency to this oscillating assembly so that it slightly exceeds the frequency of the supply current, and then, to correct at each moment the stiffness of said oscillating assembly by means of two elastic elements 26, 27. The latter are fixed in the frame 5 and placed on either side of the abutment formed by the inertia mass 25. They are separated to an extent so that this mass cannot oscillate except according to a given amplitude by regulating the voltage of the supply current. When the amplitude tends to increase, the mass 25 abuts, at the end of the stroke, against the elements 26, 27, which increases the stiffness of the oscillating assembly while consequently causing a diminishing of the amplitude.

The device described above with reference to FIG. 1, is thus intended to apply to the test-piece 1, two algebraically added forces F_s and F_d . These forces are shown by the diagram of FIG. 9, in function of the elongation of the elastic component 3. The forces F are shown in ordinates and considered as positive (FIG. 1) when they stress the test-piece 1 in pulling, then the corresponding elongations x are shown in abscissae and considered as positive (FIG. 1) when they lead to a reduction of the tension of the elastic component 3.

This diagram clearly shows, on the one hand, that the force F_s is constant and adjustable for intensity by means of the ring 9, then, on the other hand, that the force F_d is linearly variable, the remanence of the elastic phenomenon being able to be considered as negligible. The mean value F_1 of this force F_d is adjustable by means of the coupling, or turnbuckle 21 and its variation, between maximum F_M and minimum F_m limits, is also adjustable by acting on the supply voltage which causes the amplitude a of the vibratory movement of the oscillating assembly to vary. The force F_d is also periodic and its frequency is regulated by modifying the frequency of the supply voltage and, in correspondence, the frequency belonging to said oscillating assembly (elastic components 3, 22 of different stiffnesses and inertia mass 25).

In the example shown, the test-piece 1 is stressed in traction by the elastic component 3 and in compression by the elastic element 2. Nothing prevents the effects of these elastic components from being inverted or else they can be exercised in the same direction: both in traction or both in compression.

In any case, the forces F_s and F_d algebraically added and their resultant force F_r can be regulated, by the means analyzed above, for producing on the test-piece 1 varied effects whose respective behaviour are shown by the characteristic curves of FIGURES 10 to 15.

In FIG. 10, the resultant force F_r varies between two positive limits F_M , F_m for pulling the test-piece in undulated traction (curve 28);

In FIG. 11, the resultant force F_r varies between a positive maximum limit F_M and a zero minimum limit F_m for pulling the test-piece in repeated traction (curve 29);

In FIG. 12, the resultant force F_r varies between a positive maximum limit F_M and a negative minimum limit F_m for acting upon the test-piece in alternating traction-compression;

In FIG. 13, the resultant force F_r varies between two

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symmetrical limits F_M and F_m for acting upon the test-piece in pure or symmetrical alternating traction-compression (curve 31);

In FIG. 14, the resultant force F_r varies between a zero maximum limit F_M and a negative minimum limit F_m for acting on the test-piece by repeated compression (curve 32);

In FIG. 15, the resultant force F_r varies between two negative limits F_M and F_m for acting upon the test-piece by undulated compression (curve 33).

This device thus enables test-pieces to undergo endurance tests according to varied types of stresses.

FIGS. 2 to 4 show a second form of embodiment of the device putting the method of the invention into operation, more particularly for the simultaneous testing of two test-pieces 34, 35 according to any two different types of stresses (curves 28 to 33).

In the second form, the elastic components 3, 22 are also mounted in opposition, but are placed on either side of the shuttle 18 of the electro-magnetic circuit 13. The elastic component 3 cooperates with the elastic element 2 for acting on the test-piece 34, and to this end, said elastic components 2, 3 are associated with the elements 4 to 11, 20, 21, 25 to 27 described for the first form of embodiment. In a similar manner, the elastic component 22 cooperates with an elastic element 36 with elastic action for acting upon the test-piece 35, and to this end said elastic components 22, 36 are associated with elements similar to the preceding ones and denoted by the same marks with the indication of a letter a for differentiating them: 4a, 6a to 11a, 20a and 21a.

So that the electro-magnetic circuit 13, formed identically or in another manner, operates normally, the elastic components 3, 22 and the two parts, separated by the shuttle 18 form the new oscillating assembly, having the same dynamic characteristics. Hence, these elastic components 3, 22 exert on the test-pieces 34, 35 identical periodic forces F_d , F'_d but in phase opposition. On the other hand, the initial tension of the elastic elements 2, 36 can be regulated differently, so that the test-pieces 34, 35 are acted upon by different static forces F_s and F'_s .

Consequently, the periodic forces F_R , F'_R applied to the test-pieces 34, 35 and resulting from the algebraic sum of the forces F_d and F_s , F'_d and F'_s can be differentiated for carrying out two types of tests according to the curves 28 to 33.

FIGS. 3 and 4 show a method of constructing the second form of embodiment of the device. The frame 5 is made of a metal section 37 to which uprights 38 to 44 are added. The uprights 38, 39 support two rings 45, 46 forming the armature 17 and securely holding the coils 15, 16 and the annular magnet 14. The fixed part of the electromagnetic circuit 13 thus formed confines the channel 19 whose ends are provided with bearing 47, 48 and linings 49. The shuttle 18 has the shape of a tube integral with a sleeve 50 for fixing it onto a cylindrical monolithic bar 51 replacing the two rods 20 and 20a. This bar is guided in the bearings 47, 48.

The inertia masses 25 are formed by one or more washers secured between two nuts 52, 53 screwed onto a threaded sleeve 54 and tightened. The nuts thus allow the sleeve 54 to be tightened on the bar 51 and to hold the washers of the mass 25.

The elastic elements 26 and 27 of the amplitude regulator are made, either by plugs of flexible material, such as rubber, or of abutments subjected elastically by springs, for example. These elastic elements are extended in slides 55, 56 guided in the upright 40 to enable the regulating of the amplitude to be stabilized in relation to the supply current voltage.

The side-plate 6 or 6a of each support 4 or 4a is prolonged by a cylindrical stem 57 guided in a bearing 48 of the upright 42 and carrying a journal 59 for guiding the free end of the rod 11 or 11a corresponding. The elastic element 2 or 2a associated with the support is

formed by a spiral spring inserted between the adjustment ring 9 or 9a screwed into the upright 41 and the side-plate 6 or 6a. As the actuating force of this spring is essentially static, the side-plate is not pivoted.

The elastic component 3 or 3a inserted between the side-plate 7 or 7a and the plate 10 or 10a corresponding, is formed by a helical spring. During its periodic distortion, it tends to cause said side-plate and plate to pivot relatively with regard to each other, which has the effect of causing the supports 4 to pivot on themselves. This effect can be damped out if the springs 3 and 3a are wound with contrary pitches, so that their angular distortions compensate one another.

Other methods of effecting the mounting of the elastic components 3 and 3a are shown in detail in FIGS. 5 to 8 for eliminating their reactions on the supports 4 and 4a;

In FIG. 5, each dynamic action elastic component is made by two helical springs 61 and 62 coiled with contrary pitches and bearing on an intercalary washer 63 slipped onto the corresponding rod 11 or 11a. These springs are inserted between the side-plate 7 or 7a and the plate 10 or 10a associated with said rod;

In FIG. 6, each dynamic action elastic component is made by two spiral springs 64 and 65 wound with contrary pitches and whose coiling diameters are different. These springs are placed coaxially to the rod and inserted between the corresponding side-plate and plate;

In FIGS. 7 and 8, each dynamic action elastic component is made by a spiral spring 66 inserted between the corresponding plate 10 or 10a and a washer 67 applied by means of a revolving abutment to the associated side-plate 7 or 7a. In FIG. 7, the revolving abutment is a ball bearing 68, and in FIG. 8, a ring 69 of synthetic material such as nylon, Teflon, etc.

The stem 57 of each support 4 or 4a and another support 70 added onto the upright 44 are provided with seizing components 71, 72 cooperating with a double seizing component 73 for holding the corresponding test-piece 34 or 35 and a reference test-piece 74 on which an extensometer—usually called a restraint or stress gauge—is placed. The double component 73 is housed in a groove 75 confined by the upright 43 for preventing its lateral displacement. All these seizing components may be made by jaws, grips or clamps tightened by means of screws on the cooperating part.

Various modifications may moreover be applied to the forms of embodiment shown and described in detail, without going outside of the scope of the invention.

I claim:

1. An endurance testing machine comprising a rigid frame, a longitudinally reciprocable support member mounted on said frame for securement to one end of a test-piece whose other end is fixed, said support member including a pair of spaced plates secured to each other by rigid means, a first spring device interposed between one of said plates and an adjustably positioned member on said frame to apply a first force to the support member and a secured test-piece in one direction, a second spring device having one end bearing against the other of said plates to apply a second force to the support member in opposition to said first force, a freely mounted, longitudinally disposed rod bearing against the other end of said second spring device, a third spring device engaged between a collar on said rod and a second adjustably positioned member on said frame so as to oppose said second spring device, means connected to said rod for oscillating the rod longitudinally, and means on said rod to adjust the tension of said second and third spring devices and thereby said second force applied to the support member.

2. An endurance testing machine as set forth in claim 1 wherein is further provided elastic stop means to limit the amplitude of oscillation of said rod and thereby regulate the dynamic cyclic stresses applied to a test-piece.

3. An endurance testing machine as set forth in claim 2

in which said stop means to limit the amplitude of oscillation comprises two elastic abutments carried by said frame and a rigid member carried by said rod, said rigid member being in part inserted between said elastic abutments.

4. An endurance testing machine as set forth in claim 1 wherein said electromagnetic means comprises a motor having a magnetic circuit supplied with A.C. and fixedly connected to said frame and an oscillating armature rigidly fixed to said rod.

5. An endurance testing machine as set forth in claim 4 in which said rod comprises two aligned rod portions having threaded ends connected by a turnbuckle forming said means to adjust the tension of said second and third spring devices, said third spring device bearing against a threaded ring screwed in said frame and forming said second adjustably positioned member, whereby said armature fixed to said rod may be centered with respect to said magnetic circuit for any position of said turnbuckle.

6. An endurance testing machine as set forth in claim 1 wherein a mass is additionally provided on said rod to cause oscillation thereof at determined adjustable natural frequency.

7. An endurance testing machine comprising a rigid frame and rigidly connected therewith a magnetic circuit including windings supplied with adjustable A.C. voltage, a magnetic armature mounted within said magnetic circuit to be reciprocated longitudinally of the frame when said windings are energized, two longitudinally extending rods secured to said armature having abutment collars and extending respectively on both sides of said armature, two springs respectively fitted on said two rods each having one end bearing against an abutment collar, a ring member loosely fitted on each one of said rods between the armature and one spring and engaging the other end thereof, two floating support members for connection to two test-pieces and movably carried by said frame near said abutment collars, longitudinally extending means rigidly connecting each said ring member to the associated floating support member to transmit the action of said springs thereto, two loading springs inserted respectively between said floating support members and a pair of adjustable stop elements secured to said frame, means for removably securing at least one test-piece between each of said floating support members and an associated rigid body carried by the frame, and means for adjusting the tension of said springs associated with said rods and armature and for centering the armature with respect to said magnetic circuit when at rest.

8. An endurance testing machine according to claim 7 in which each one of said two rods connecting said springs to said armature comprises two sections respectively connected together by adjustable connectors selectively operable to adjust the length of said rods.

9. An endurance testing machine as set forth in claim 7 further comprising revoluble abutments positioned between said springs fitted on said rods and said ring members.

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