June 28, 1960 E. CHAPOUX 2,942,441

TORQUE LIMITING DEVICE

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FIG.1

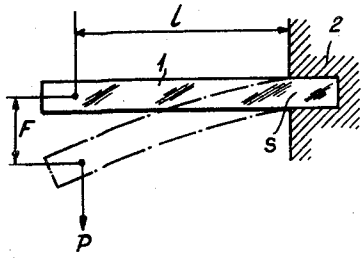


FIG.2

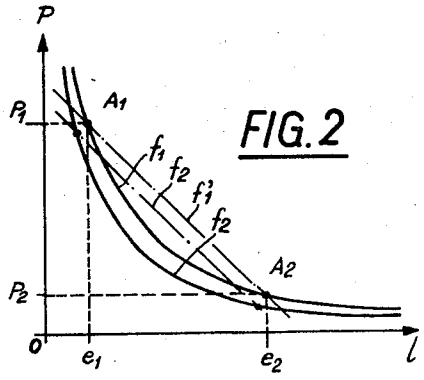


FIG.3

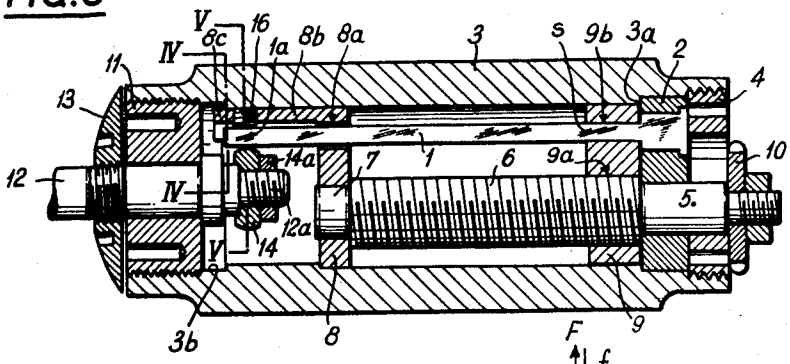


FIG.4

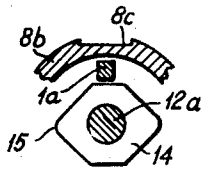


FIG.5

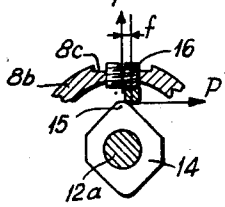
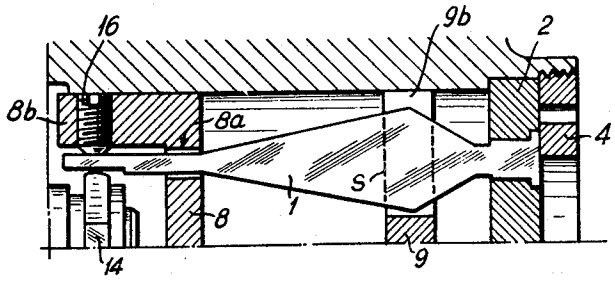


FIG.6



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FIG. 7

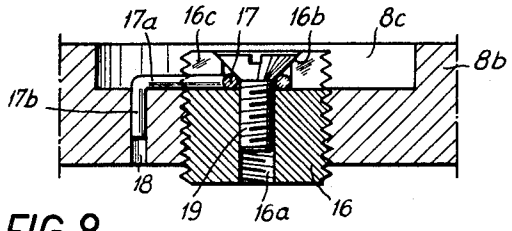
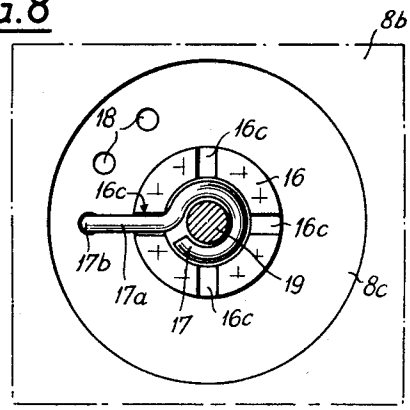


FIG. 8



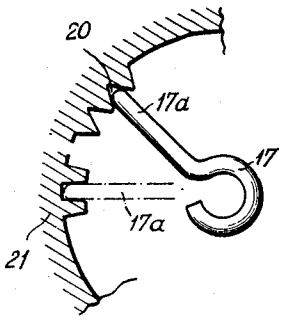
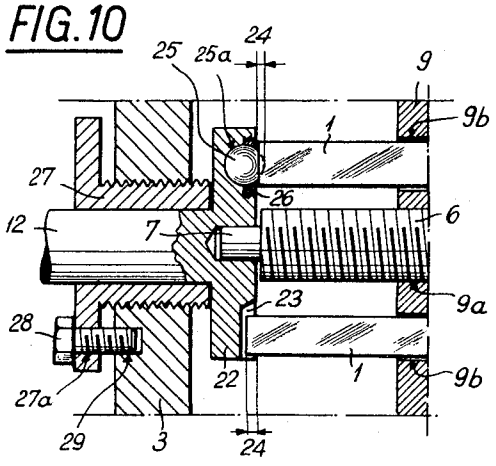


FIG. 9

FIG. 10



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United States Patent Office

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TORQUE LIMITING DEVICE

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5 Claims. (Cl. 64—29)

Torque limiting devices of conventional types are hardly accurate or faithful and their adjustment is a difficult matter.

My invention has for its object an arrangement for limiting the torque transmitted to a driven member by a driving member, said arrangement showing none of the prior drawbacks while its design is furthermore very simple.

According to my invention, there is provided for coupling two such members at least one yielding blade housed in one of the latter and the free end of which engages a cam surface rigid with the other member, in a manner such that the blade may bend as a function of the torque to be transmitted so as to disengage the cam and to break the kinematic connection between the driving and driven members when the sag of the blade has reached a predetermined value.

It is a known fact that the sag assumed by a blade housed in its support when subjected to a predetermined stress is reversely proportional to its momentum of inertia and is proportional to the third power of the length separating the point of application of the stress from the cross-section in which the blade is fitted.

By causing the member such as a rotary shaft which receives or transmits the torque which is to be limited to act on blade of predetermined characteristics, the arrangement is such that said shaft is released by the blade when the latter has reached a sag which is also of a predetermined value and it is therefore possible to limit very simply the torque transmitted to said shaft or received by the latter.

Furthermore, through a suitable modification of the length separating the point of application of the stress acting on the blade from the cross-section thereof which is held in its housing, it is possible to adjust as desired the value of the stress for which the kinematic connection between the driving member and the driven member breaks.

It is also possible to define the law governing the variations of the cross-section of the blade along its length in a manner such as to obtain for instance a linear law defining the torque for which the blade assumes a predetermined sag as a function of the distance separating the point of application of the torque from the cross-section of the said blade which is engaged by the housing.

My improved device may also include means allowing a compensation of the play appearing between its different elements and ensuring an auxiliary adjustment.

The torque limiting device forming the object of my invention is intended for various applications and in particular it may be used to considerable advantage with dynamometric tools, such as screw-drivers and the like.

I have illustrated by way of example, in the accompanying drawings, various embodiments of my improved device together with modifications thereof. In said drawings:

Fig. 1 is a diagrammatic showing illustrating the bending of a blade fitted through one of its ends.

Fig. 2 is a graph showing the intensity of the force required for bending by a predetermined amount a blade, a cross-section of which is set in a housing as a function of the operative length of said blade.

Fig. 3 is a longitudinal sectional view of a first embodiment of the invention.

Fig. 4 is a sectional view thereof through line IV—IV of Fig. 3.

Fig. 5 is a sectional view through line V—V of Fig. 3, the cam occupying a position different from that which it is assumed to occupy in Fig. 4.

Fig. 6 is a longitudinal sectional view of a modification of the embodiment illustrated in Figs. 3 to 5.

Figs. 7 and 8 are partial views on a larger scale, respectively in sectional view and in plan view, showing means for locking the adjusting screw.

Fig. 9 is a modification of Fig. 8.

Fig. 10 is a partial longitudinal sectional view showing two modifications of the cam.

It is a well-known fact that when an elastic blade 1 housed inside a support 2 is subjected to a stress P directed perpendicularly to its axis and applied at a distance l from the cross-section s through which the blade is housed, the sag f assumed by said blade under the action of the stress P may be calculated by the formula:

$$P=\frac{3fEI}{l_3}$$

E being the modulus of elasticity of the blade and I its momentum of inertia with reference to the bending axis.

Assuming the sag has a constant value, the preceding relationship may be written:

$$\frac{P=kl}{l_3}$$

and, if it is also assumed that the blade has a uniform cross-section,

$$P=\frac{k'}{l_3}$$

It is therefore possible to modify the stress producing a predetermined bending of the blade through a modification of l which is the distance separating the point of application of the force from the cross-section of the blade engaged by its housing.

It is also possible to define the law of variation of the momentum of inertia of the cross-section of the blade as a function of l so that P may be a linear function of l, if f is assumed to be constant. It is thus possible to make the adjustment of the force or stress P easier when the value of the latter is somewhat considerable, since such an adjustment would not be an easy matter in the case of a blade having a uniform cross-section as in such a case, and as illustrated by the graph of Fig. 2, the curves f=constant extend asymptotically with reference to the axis of ordinates which is that giving the values of the force P.

This graph shows curves $f1$, $f2$ corresponding to a blade having a constant cross-section on the one hand and straight lines $f'1$, $f'2$ corresponding to a blade the cross-section of which has been defined in a manner such that the force P may be proportional to l.

It is possible to select among the various curves $f1$, $f2$, the useful ranges P1, P2 corresponding on one of the curves f to the values l_1 and l_2 which define the points A1 and A2 for a blade having the predetermined cross-sectional area at A1 and A2. It is then sufficient, if it is

desired, to obtain a linear variation of $P=f(l)$ to make I vary.

The arrangement illustrated in Fig. 3 is adapted to limit the torque transmitted by the shank of a dynamometric screw-driver to its head. It includes a blade **1** fitted inside a support **2** housed inside the cylindrical body **3** and held in position by a threaded plug **4**. The support **2** engages the shoulder **3***a* formed inside the front end of the body **3**. Through the support **2**, there extends the shank **5** of a screw **6** the outer end **7** of which is revolubly carried inside a bearing **8** fitted in the body **3**, the blade **1** passing through the opening **8***a* of said bearing, which bearing is wide enough to allow the blade to bend freely.

Inside the cylindrical body **3** is mounted a slider **9** fitted over the screw **6** as provided by its taped bore **9***a*. Said slider is slotted at **9***b* to allow the blade **1** to slide through it under slight friction conditions. It is assumed in the present case that the blade has a constant cross-section. It is possible to shift the slider **9** longitudinally inside the body **3** through the agency of a control knob **10** carried by the screw **6**. This leads consequently to a modification in the length separating the free end of the blade from the actual section *s* which is housed at the point at which the blade passes out of the slider.

The outer end of the body **3** contains a bearing **11** screwed into the said end of the body **3** and engaging a shoulder **3***b* formed inside the latter. Said bearing **11** carries revolubly a shaft **12** held in position inside the bearing **11** through the agency of the nut **13**. Said shaft **12** is integral with the shank of a screw-driver, while the head of the latter, which is not illustrated, is rigid with the body **3**.

At its inner end **12***a*, the shaft **12** carries a cam **14** which is locked in position by a nut **14***a* threadedly engaging said end **12***a* of the shaft. This cam (Figs. 4 and 5) includes two diametrically opposed bosses **15** adapted to engage the free end **1***a* of the blade **1**.

As illustrated in Fig. 5, when the cam **14** exerts through one of its bosses **15** a stress P on the blade **1**, the latter bends until the torque exerted by the shaft gives the blade a sufficient bend for the boss **15** to move past said blade. The torque is then equal to the product $P \times r$, *r* being the distance separating the axis of the shaft from the apex of the boss and P the force exerted on the blade.

When the boss **15** has thus moved beyond the blade, the kinematic connection between the shank and the head of the screw-driver is broken. This leads to a release showing that it is no longer possible to act on the tool.

The shifting of the slider **9** modifies the value of the force P for which the desired sag is reached and which corresponds consequently to the limitation required for the torque $P \times r$.

The value of this torque may be defined by the position assumed by the slider inside the casing or again by the angular setting of the control knob **10**. This position may be accurately measured for instance through the agency of a vernier which leads to a highly accurate adjustment.

In the preceding disclosure, it has been assumed that the blade was moving under the action of the cam **14** tangentially with reference to the latter, so that it cannot move away from the cam in the direction of the arrow F of Fig. 5. In order that the blade may actually move in this tangential direction, an adjusting screw **16** engaged by the back of the blade is carried by an extension **8***b* of the bearing **8**. Said srew allows furthermore cutting out the clearance produced by the wear of the different parts and also providing a highly accurate complementary adjustment defining the value of the limit torque allowed while leaving a greater degree of freedom for the blade in the direction of the arrow F.

Fig. 6 shows a blade **1** the cross-section of which is variable and is such as will provide a linear relationship between the limit torque allowed and the length separating the point of application of the force P from the cross-section *s* through which the blade is housed.

Since the modification in length of said blade is obtained through a shifting of the slider, the modification in the cross-section of the blade is obtained by acting in a single direction on the size of the blade, which direction in the present case extends in the plane of the drawing while the thickness of the blade remains constant and is equal to the breadth of the slot **9***b* of the slider. The blade engages also an abutment formed by the screw **16** as in the preceding example.

In all cases, it is essential for the screw **16** to be locked on the member carrying it in an efficient manner and in an accurately defined position.

It is possible to resort to this end to any conventional means, but the locking means illustrated in Figs. 7 and 8 are of particular advantage. In said figures, the screw **16** is provided centrally with a tapped opening **16***a* the pitch of which is preferably different from that of the outer thread on the screw. It is also provided in its outer end with a recess **16***b* the walls of which are provided with radial slots **16***c*.

The recess **16***b* carries a locking spring **17** including a shank **17***a* extending through one of the slots **16***c* and having its tail end **17***b* fitted inside an opening **18** formed in the extension **8***b* of the bearing **8**. Said extension is provided with a plurality of such openings **18** so as to provide a sufficient range of adjustment and it is furthermore provided with a recessed section **8***c* inside which the spring shank **17***a* is carried outside the projecting section of the screw **16**. The spring **17** is in fact held in position by a screw **19** engaging the tapped opening **16***a*.

Instead of anchoring openings **18**, it is possible to provide anchoring notches **20** or **21** as illustrated in Fig. 9.

The arrangement which has just been described may be simplified by cutting out the slider **9** and its adjusting screw **6**, the adjustment of the limit torque being obtained then merely through the screw **16**.

It is possible to provide the cam **14** with a number of bosses which is different from two and it is also possible to provide a plurality of blades such as **1**.

Figure 10 illustrates such a modification provided with a plurality of blades **1**. In this case, the shaft **12** terminates with a plate **22** inside which is revolubly fitted the end **7** of the screw **6** serving for the adjustment of the slider **9**.

Various means may be resorted to for urging the plate **22** against the blades **1**.

As illustrated in the lower part of Fig. 10, the plate **22** may be provided with bosses **23** between which are fitted the terminal sections **24** of the corresponding blades, the length of said sections **24** being defined in a manner such that the blades move past the plate for a predetermined value of their sag. The bosses may as well be formed by balls **25** as illustrated in the upper part of Fig. 10, said balls being held inside corresponding recesses **25***a* of the plate by a covering plate **26** and projecting by a value equal to the length of the sections **24** beyond the ends of the blades.

The outer surface of the plate **22** abuts against a nut **27** screwed into the wall of the body **3** and held in position by a set screw **28** extending through a bore **27***a* in the flange of the nut and screwed into a tapped opening **29** in the body **3**. A number of balls **27***a* and holes **29** may be provided so as to allow compensation of play and further adjustment.

Obviously, the use of my improved arrangement is by no means limited to the operation of tools and it may be used in any type of transmission while its effects are by no means limited to the breaking of a kinematic connection between two parts and it may as well engage or release any type of mechanism such as a safety mechanism for instance.

What I claim is:

1. A torque-limiting device comprising a hollow cylindrical body including a cover at each end, a shaft rotatably carried inside one of said covers and including a terminal section projecting slightly into said body, a flat yielding blade fitted in the other of said covers and extending freely inside the body up to a point in transverse registery with the terminal section of the shaft, a cam element rigid with the shaft and adapted to be operatively engaged by the free end of said blade registering with the terminal section of the shaft to allow said blade to transmit a torque between the body and the shaft while bending said blade until the blade being shifted onto the point of the cam outline furthest removed from the axis of the shaft for a predetermined maximum torque moves off the cam and releases the shaft, a stop cooperating with the outer surface of the blade and holding the latter in a position tangent with reference to the path followed by the outermost point of the cam element, and means for adjusting the location of the stop radially with reference to said path.

2. A torque-limiting device comprising a hollow cylindrical body including a cover at each end, a shaft rotatably carried inside one of said covers and including a terminal section projecting slightly into said body, a flat yielding blade fitted in the other of said covers and extending freely inside the body up to a point in transverse registry with the terminal section of the shaft, a cam element rigid with the shaft, and adapted to be operatively engaged by the free end of said blade registering with the terminal section of the shaft to allow said blade to transmit a torque between the body and the shaft while bending said blade until the blade being shifted onto the point of the cam outline furthest removed from the axis of the shaft for a predetermined maximum torque moves off the cam and releases the shaft, an adjustable stop cooperating with the outer surface of the blade and bending the latter tangentially with reference to the path of the outermost point of the cam surface.

3. A torque-limiting device comprising a hollow cylindrical body including a cover at each end, a shaft rotatably carried inside one of said covers and including a terminal section projecting slightly into said body, a flat yielding blade fitted in the other of said covers and extending freely inside the body up to a point in transverse registry with the terminal section of the shaft, a cam element rigid with the shaft, and adapted to be operatively engaged by the free end of said blade registering with the terminal section of the shaft to allow said blade to transmit a torque between the body and the shaft while bending said blade until the blade being shifted onto the point of the cam outline furthest removed from the axis of the shaft for a predetermined maximum torque moves off the cam and releases the shaft, an intermediate support carried slidingly inside the hollow body and provided with a perforation freely engaged by the blade, means for adjusting the location of said intermediate support longitudinally of the blade, an extension of said support extending alongside the blade outside the latter and provided with a threaded hole facing the terminal section of the shaft, a screw adjustably fitted in the threaded hole of said extension and cooperating with the outer surface of the blade near its free end to bend the latter tangentially with reference to the cam surface.

4. A torque-limiting device comprising a hollow cylindrical body including a cover at each end, a shaft rotatably carried inside one of said covers and including a terminal section projecting slightly into said body, a flat yielding blade fitted in the other of said covers and extending freely inside the body up to a point in transverse registry with the terminal section of the shaft, a cam element rigid with the shaft, and adapted to be operatively engaged by the free end of said blade registering with the terminal section of the shaft to allow said blade to transmit a torque between the body and the shaft while bending said blade until the blade being shifted onto the point of the cam outline futhest removed from the axis of the shaft for a predetermined maximum torque moves off the cam and releases the shaft, an intermediate support carried slidingly inside the hollow body and provided with a perforation freely engaged by the blade, means for adjusting the location of said intermediate support longitudinally of the blade, an extension of said support extending alongside the blade and provided with a threaded hole facing the terminal sections of the shaft and blade, a screw adjustably fitted in the threaded hole of said extension and cooperating with the outer surface of the blade near its free end to bend the latter tangentially with reference to the cam surface, said screw being provided with a cylindrical coaxial recess in its head, an annular spring housed inside said recess and including a shank extending through the wall in the screw recess, a set screw holding the annular spring inside said recess coaxially therewith and means rigid with the extension of the intermediate support, in which means the shank of the spring is anchored.

5. A torque-limiting device comprising a hollow cylindrical body including a cover at each end, a shaft rotatably carried inside one of said covers and including a terminal section projecting slightly into said body, a flat yielding blade fitted in the other of said covers and extending freely inside the body up to a point in transverse registry with the terminal section of the shaft, a cam element rigid with the shaft, and adapted to be operatively engaged by the free end of said blade registering with the terminal section of the shaft to allow said blade to transmit a torque between the body and the shaft while bending said blade until the blade being shifted onto the point of the cam outline furthest removed from the axis of the shaft for a predetermined maximum torque moves off the cam and releases the shaft, an intermediate support carried slidingly inside the hollow body and provided with a perforation freely engaged by the blade, means for adjusting the location of said intermediate support longitudinally of the blade, an extension of said support extending alongside the blade and provided with a threaded hole facing the terminal section of the shaft, a screw adjustably fitted in the threaded hole of said extension and cooperating with the outer surface of the blade near its free end to bend the latter tangentially with reference to the cam surface, said screw being provided with a cylindrical coaxial recess in its head, an annular spring housed inside said recess and including a shank extending through the wall in the screw recess, a set screw holding the annular spring inside the said recess coaxially therewith, the pitch of said screw being different from that of the first-mentioned adjustable screw, and means rigid with the extension of the intermediate support, in which means the shank of the spring is anchored.

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