

TITLE

TORQUE REGULATING DEVICE

DESCRIPTION

The present invention relates to a torque regulating
5 device.

BACKGROUND OF THE INVENTION

The device of the present invention is specifically
intended for use in paying out and recovering electrical
cables (and also hoses). However, it is to be appreciated
10 that the present invention is of much wider applicability.
Generally, cables are recovered on moving machinery by
reeling onto a parallel reel (utilising a layered mechanism
to give uniform layering) or onto a radial reel, where, in
most cases, the cable lays vertically on a single plane.

15 Other types are "standard" lay, where cable lays
horizontally in three then two configuration and random lay
where cable lays as it falls.

All the above types are in general use as each has specific
advantages either in cost saving, dimensions, or cable
20 tension reduction.

The prime requisite for a cable reel is to payout and
recover cables without causing excessive tension in the
cable itself. Cable manufacturers have developed cable
which can take quite high tensions and are very flexible,
25 but the upper limits of curvature and tension are well
defined. Any excursion beyond this limit will lead to
premature failure of a very costly item.

For short runs of cable and low frequency of use, spring

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reels were developed and these are quite satisfactory. The demand for reels which could handle long runs of cable, high lift of cable and high duty cycles led to the development of several types of reel drives, each with
5 claims to satisfactory operation which in many cases were not justified.

The first were "Torque Motors" and hydraulic drives. Both these types are still in use, although hydraulic drives are uncommon. They power the reel in payout and recovery and
10 by the use of sensors which "read" cable tension, try to control the speed to keep cable tension within acceptable limits. The cable tension sensors vary from simply mechanical devices to highly sophisticated micro processor systems with continuous monitoring. Also, control of
15 starting torque and braking torque still seems to be a problem as the inertia of the reel and drives is not fully controlled and cable overtension with subsequent failure is common.

A later development in cable reeling was a friction drive
20 unit which slipped when torque exceeded a certain value. The cable was reeled in under power by the drive unit and payed-out by the cable driving the reel. One of these units used a spring loaded steel disc bearing on one side of a bronze worm in the drive unit. Lubrication was by the
25 oil normally in the gear unit and the whole unit was enclosed. This unit depends on the slipping faces being lubricated at all times to prevent wear.

However, to prevent hydro-dynamic lubrication of the rubbing faces, where friction would be too low to be

practical, fairly high unit pressures are used. While running, the drive gives a reasonably constant torque during payout and recovery, but if the cycle is interrupted for a short time, the oil film is partly extruded from between the slipping faces, the slipping faces contact each other and friction increases. On restarting, the payout cable tension to overcome this friction rises up to five times the normal running tension and this is rarely acceptable.

5 Further, if air cooling is used for the slipping faces, the units become larger and more expensive.

A later development of the friction drive was an air-cooled disc with circular asbestos friction pads uniformly loaded onto the disc with stacks of Belville spring washers. Each spring stack had a torque range and the torque could be adjusted within this range by a gear and threaded pressure plate. Being dry, this unit did not have the fault of high starting torque inherent in the oil lubricated unit. The unit was ideal within its torque and power range and, although fairly complicated and expensive, was reliable and had an excellent working life. The banning of the use of asbestos meant that the pad friction lining material had to be changed. The performance of the unit remained unchanged but the life of the friction pads and discs was considerably reduced and any competitive edge was lost.

25 Research is continuing for a suitable friction material. The present invention seeks to overcome or at least alleviate some of the aforementioned problems of the prior art.



SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there is provided a torque regulating device characterised by a disc arranged to be fixedly attached to a shaft,
5 friction material having a low coefficient of friction which remains substantially constant whether the friction material is dry or lubricated, a gear wheel means arranged to be mounted about the shaft, the friction material being disposed between the disc and the gear wheel means, and
10 means being provided for clamping the friction material between the disc and the gear wheel means.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described by way of example, with reference to the accompanying drawings in
15 which:

Figure 1 is an upper perspective view of a first embodiment of a torque regulating device in accordance with the present invention in an exploded condition;

Figure 2 is a sectional view of the torque regulating
20 device of Figure 1;

Figure 3 is an upper perspective view of a second embodiment of a torque regulating device in accordance with the present invention in an exploded condition;

Figure 4 is a sectional view of the torque regulating
25 device of Figure 3;

Figure 5 is an upper perspective view of a third embodiment of a torque regulating device in accordance with the present invention in an exploded condition;

Figure 6 is a sectional view of the torque regulating

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device of Figure 5; and

Figure 7 is a side view of a gearbox partially broken away incorporating the device of Figures 1 and 2, Figures 3 and 4 or Figures 5 and 6.

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DESCRIPTION OF THE INVENTION

Shown in Figure 1 is a first embodiment of a torque regulating device 10 comprising an annular pressure plate 12 keyed to an externally threaded sleeve 14, by a plurality of cylindrical roller keys 18. Each key 18 is received in a respective external keyway 19 in the sleeve 14 and a respective internal keyway 20 in the pressure plate 12. Spaced around the circumference of the pressure plate 12 are a plurality of apertures 26 each able to receive a respective spigot 28 passing through a spring means in the form of a stack of Belville washers 30. The spigots 28 are located around the circumference of a first annular disc 34. The disc 34 is keyed to the pressure plate 26 by the spigots 28. Thus, the pressure plate 26 and the disc 34 rotate in unison.

20 Adjacent to the disc 34 is a first annular disc 40 of friction material. The disc 40 is formed of a low friction material of a type which has a low coefficient of friction which remains substantially constant regardless of whether the disc 40 is dry or lubricated. Typically, each disc 40 is formed of an ultra high molecular weight polyethylene (UHMW PE).

The low friction material is selected according to the working conditions of the device 10, as will be described hereinafter.

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The disc 40 bears on a web 42 of a gear wheel 44 having peripheral teeth 46. The gear wheel 44 is carried on a bearing 48 which is mounted about a step 49 of the sleeve 14 (see Figure 2) and is thus able to rotate relative to the shaft.

A second annular disc 50 formed of low friction material, similar to the disc 40 bears upon the opposite side of the web 42. The disc 50 is adjacent a second annular disc 52 which is formed integrally with the sleeve 14. The low friction discs 40 and 50 sit on the bearing 48 as can be seen in Figure 2 so that the discs 40 and 50 are isolated from rotation of the shaft.

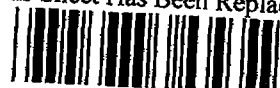
The disc 52 has holes 60 to allow lubricating liquid, such as oil, to pass therethrough and cool the disc 50.

The web 42 has inwardly facing notches 61 adjacent the periphery of the bearing 48, to allow passage of lubricating liquid to cool the disc 40. It has been found that oil is not able to pass through the bearing 48 at high speed. The notches 61 allow the oil to pass through the disc 40 to prevent it overheating.

Further, the discs 40 and 50 have radial grooves 51 to allow passage of lubricating liquid. The radial grooves 51 are cut on both sides of the discs 40 and 50 and are staggered on opposite sides thereof as can be seen in Figure 1.

To cool the faces of the discs 40 and 50 oil flows into the radially inclined oil passages 60. The oil flows radially through the passages 60 assisted by centrifugal force and passes to the interior of the apparatus adjacent the

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bearing 48.

At slow speeds oil passes through the bearing 48 and then radially through the outer faces of the discs 40 and 50 finally discharged through a gap between the disc 34 and
5 the gear wheel 44.

At high speeds churning of the oil in the bearing 48 prevents oil flow and there is a tendency for overheating to occur. Thus, the notches 61 are provided in the web 42. The notches 61 are located outwardly of the bearing 48
10 and are proportioned to divide oil flow between the friction faces of both discs 40 and 50.

The inner diameter of the discs 40 and 50 clear the notches 61 so that oil can enter the radial slots 51 or both faces of the discs 40 and 50.

15 The threaded sleeve 14 passes through the disc 34 and the pressure plate 12.

An internally threaded locknut 62 threadedly engages the threaded sleeve 14 and bears against the pressure plate 12 to thereby clamp the discs 40 and 50 against the web 42. A
20 lockwasher 63 is disposed between the locknut 62 and the pressure plate 12. The lockwasher 63 has an axially projecting tang 63a which is arranged to be disposed in one of the keyways 20 and a plurality of radially projecting tangs 63b. The locknut 62 contains a plurality of spaced
25 peripheral notches 63c each arranged to receive a tang 63b. In this way, the locknut 62 is prevented from inadvertently loosening or tightening.

It is possible to deliberately loosen or tighten the locknut 62 and so vary the unit pressure clamping the discs

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40 and 50 against the web 42.

Shown in Figure 7 is a gearbox 64 incorporating the torque regulating device 10, of figure 1. The gearbox 64 comprises a casing 66 and bearings 68 only (one of which
5 can be seen), internal of the casing 66, to support a shaft 69. The sleeve 14 is keyed to the shaft 69 with a rectangular key and returned with a circlip.

The shaft 69 has a worm gear between the bearings 68, to engage a ring gear keyed to an output shaft 74. It is to
10 be appreciated that, as an alternative, a bevel helical gear combination may be used instead of the worm gear and ring gear combination.

An external motor is attached to the casing 66. A gear 80 is keyed to a motor shaft 78 to engage the gear teeth 46 of
15 the gear wheel 44. Where lower speeds are required the motor may be replaced with a gear motor.

Lubricating liquid, such as oil, is contained within the casing 66 to cool the torque regulating device 10 and simultaneously lubricate the bearings and gear teeth within
20 the casing 66. This cooling occurs because the device 10 is at least partially immersed in the cooling fluid.

Usually, the device 10 is almost totally immersed in the cooling fluid. However, it is to be appreciated that other methods of applying cooling fluid other than splash
25 lubrication may be used. For example, pressure lubrication by a pump may be used instead.

In use, a load (not shown) such as a reel having cable wound thereon, is attached to the output shaft 74. The motor is then activated to wind in the cable.



Referring now to Figure 1, the gear 80 engages and rotates the gear 44. The washers 30 bear on the disc 34 to urge the discs 40 and 50 onto the web 42 to thereby clamp the web 42 therebetween. By varying the number, thickness and
5 compression of the washers 30, the unit pressure clamping the discs 40 and 50 onto the web 42 may be varied. Such clamping results in a friction force which resists rotation of the gear 44 relative to the discs 40 and 50. If the torque supplied by the motor is greater than the break out
10 torque i.e. the maximum friction force supplied by the discs 40 and 50, then the shaft 69 will rotate or slip relative to the gear 44. This results in the discs 34 and 52 slipping on their respective low friction discs 40 and 50. Further, the web slips on the low friction discs 40
15 and 50.

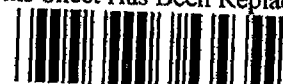
The worm gear 42 rotates in unison with the shaft 69 which cooperates with the ring gear to rotate the output shaft 74 to whereby wind in cable.

Further, the torque applied to the shaft 69 in such a
20 situation will be essentially constant at the break out torque.

This is important when winding in cable so as to wind in the cable at an essentially constant tension so as not to unduly stretch the cable. The value of the "break out"
25 torque may be varied by varying the unit pressure. This is achieved by suitably loosening or tightening the locknut 62.

However, this slip generates heat which must be dissipated. By virtue of the device 10 being at least

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partially immersed or otherwise contracted by lubricating oil, heat is carried away by the oil. Heat absorbed by the oil is then transferred to the casing 66 and thereby dissipated.

5 Further, by virtue of the material properties of the discs 40 and 50, the break out torque is substantially unaffected by the presence of lubricating oil.

Even further, when the device 10 is not operating, the washers 30 cause the lubricating oil to be squeezed out
10 from between the discs 40 and 50 and the web 42. In some prior art devices, this will increase the coefficient of friction and hence the value of the break out torque. This leads to large torque spikes or momentary increases in the value of the break out torque. This results in stretching
15 of the cable. Due to the aforesaid material properties of the discs 40 and 50 these torque spikes are substantially absent from the device 10 of the present invention.

The material 40 and 50 is preferably a low pressure high density polyethylene with a very high degree of
20 polymerisation. The molecular weight, determined by the viscosimetric method is between 3 and 8 million. As molecular weight of polyethylene increases, higher values are obtained for important properties like wear resistance and notched impact strength. These materials are commonly
25 referred to as ultra high molecular weight polyethylene (UHMW PE). They should not be confused with high molecular weight polyethylene (HMW PE) which has a molecular weight of about 500,000 and which cannot reach the level of UHMW PE in terms of properties.

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A particularly suitable UHMW PE is sold under the Trade Mark "SOLIDUR" and a particularly suitable form of "SOLIDUR" is "SOLIDUR SUPER".

5 Cooling is critical with this material and torque is governed by the applied pressure and velocity of the rubbing faces. Typically, the UHMW PE is able to withstand a temperature of about 200°C without any substantial change in its properties or structure. The majority of torque regulating applications can be met with this material.

10 The polyethylene discs 40 and 50 have been found not to wear to any appreciable extent, even under the high bearing load used and adjustment ceases to be a critical requirement, although the device 10 has an adjustment facility.

15 Alternatives to the above material were tried and initial tests were with "Teflon" coated on aluminium discs contacting a steel interface, aluminium being a good conductor to remove heat by conduction. The "Teflon" was dissolved by the lubricating oil at the temperature
20 attained.

Carbon impregnated "Teflon" failed in a similar manner. When nylon was tried it softened and extruded at well below the power requirements of the device 10.

In use, when it is desired to payout cable the motor is
25 deactivated. The output shaft 74 then rotates, to payout cable. The ring gear cooperates with the worm gear and thereby rotates the shaft 69.

The motor 76 is deactivated and locked by a brake on the motor so that the gear 44 is held substantially stationary

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by virtue of its engagement with the gear 80. Thus, when unwinding, the gear 44 is stationary and the shaft 69 and discs 40 and 50 slip relative to the shaft 69. Therefore, the torque applied to the shaft 69 is the break out

5 torque. As when winding cable in, this slip generates heat which is absorbed by the lubricating oil. Again, due to the properties of the discs of material 40 and 50 the torque applied to the shaft 69 is substantially constant at the break out torque.

10 Shown in Figures 3 and 4 is a second embodiment of a torque regulating device 100, like numerals denoting like parts. If the unit pressure is not high enough to extrude the oil, from between the slipping faces then the torque is provided by shearing of the oil film, especially at high speeds.

15 When the faces stop slipping, the oil is still between the faces and any applied torque from the reel causes slippage to occur at a very slow rate due to the hydro-dynamic (full film) lubrication.

If the reel is restrained for a few seconds, the oil
20 between the faces is partially extruded and boundary lubrication, with its high co-efficient of friction, takes over.

This characteristic is of value in high speed, low torque reels which are reversed at a high rate, as payout friction
25 is virtually zero. However, if the reel has a high vertical drop then the weight of cable will cause the reel to unwind slowly at a very low torque and dump the cable. This is sometimes undesirable, for example, in window washing applications.



To cause the device 10 to hold the cable when the drive stops, the unit pressure on the slipping faces must be high enough to extrude the oil on stopping. With the fixed areas of the annular discs of low friction material 40 and 50 (Figures 1 and 2) this would result in a "break out" torque which was too high for some applications.

Further, the annular rings tended to restrict flow of the cooling oil at high speed so the slipping speed is limited at high pressures.

Thus, it is necessary to have a sufficiently high unit pressure to extrude oil from between the discs 40 and 50 and the webs 42 and simultaneously have a sufficiently low break out torque in order not to overstress any cables. This is achieved by reducing the area of the discs 40 and 50 whilst maintaining a high unit pressure.

Reduction of the area is achieved by replacing the discs 40 and 50 with a plurality of UHMW PE buttons 102 and 104. Each button 102 and 104 has a circumferential flange 106. The buttons 102 and 104 are received and held relative to each other in annular metal button cages 108. The cages 108 have inner edges 110 and outer edges 112. The cages 108 each have a plurality of evenly spaced first apertures 114 between the inner edge 110 and the outer edge 112. The cage 108 also has a plurality of spaced second, open apertures 118. Buttons 102 or 104 disposed in the second apertures 118 extend past the outer edge 112 to contact the inner periphery of the gear 44. This centralises and locates each cage 108 relative to the web 42. This prevents the buttons 102 and 104 moving and thereby



changing the "break out" torque.

By varying the number of buttons 102 and 104, the break out torque may be accordingly varied.

As shown, the buttons 102 and 104 are arranged in staggered
5 manner. That is, the buttons 102 and 104 are arranged such that respective flanges 106 of adjacent buttons 102 and 104 are on opposite sides of the cages 108. This prevents the cages 108 contacting the web 42 and the discs 34 and 52. This complete isolation of the cages is important because
10 any wear particles resulting from such contact may contaminate the buttons 102 and 104 and alter their coefficients of friction.

In use, the device 100 operates in a similar manner to the device 10 of Figure 1.

15 However, due to the buttons 102 and 104 being spaced around the cage 108, there is a greater space for oil to flow through and cooling is thereby improved.

Further, the unit pressure clamping the buttons 102 and 104 onto the web 42 is sufficient to extrude oil from between
20 the buttons 102 and 104 and the web 42. In combination with the reduced contact area of the buttons 102 and 104, compared to the discs 40 and 50 this results in a device 100 which, in addition to the benefits of the device 10 of Figure 1, holds when it stops rather than slipping.

25 Shown in Figure 5 is a third embodiment of a torque regulating device 200, like numerals denoting like parts. In some very heavy duty applications, the temperature of the oil may exceed 200°C. This may be beyond the upper working limit of even the ultra high molecular weight

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polyethylene. Thus, use of the UHMW PE will result in unacceptable performance and/or degradation of the UHMW PE. The embodiment of Figure 5 is primarily intended for ceramic materials.

- 5 Located on each side of the web 42 is an annular recess 202 arranged to receive a respective annular ceramic disc 204. Each recess 202 locates its respective disc 204 radially of the web 42.

The pressure plate 12 and the disc 34 have been replaced by
10 an annular disc 205. The disc 205 has a plurality of evenly spaced recesses 206. Each recess 206 has an aperture 208 extending therethrough.

Slidable in each aperture 208 is a spigot 210, of a pressure button 212. Each button 212 has a steel disc 214
15 at one end of the spigot 210 and is arranged to compress a stack of Belville spring washers 216 located in a respective recess 206. A respective spigot 210 passes through a stack of washers 216 and serves to locate them in the recess 206.

- 20 On the side thereof remote from the spigot 210 each disc 214 bears on a respective ceramic button 218 which is also located in the respective recess 206. Each disc 214 urges its respective button 218 against a respective one of the annular ceramic discs 204. Each button 218 has an outer
25 face formed with a plurality of flat topped projections 219 which reduce the overall area of contact of the button 218 with the disc 204. That is the projections 219 have outer slipping faces which collectively have a smaller area than the button 212 as a whole.

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A disc 220 is constructed similarly to the disc 205 and it also contains recesses and apertures corresponding with the recesses 206 and apertures 208 of the disc 204.

The slipping faces of the projections 219 and the discs 204
5 are ground to an extremely fine surface finish typically below an average surface roughness of about 55 microns. It is to be appreciated that the ceramic buttons 218 may incorporate a spigot. This would then dispense with the need for a pressure button 212. However, at present, it is
10 relatively expensive to incorporate spigots with the ceramic buttons 218.

The discs 204 have inner faces 222 which are castellated with inwardly extending projections 224. Further, the regions 226 of the web 42 between the notches 61 have outer
15 wider portions 228. In use, the projections 224 are located between regions 226 and are positively engaged and prevented from rotating relative to the web 42 by the wider portions 228. Thus, the discs 204 are positively located. As an alternative to the positive location described, the
20 ceramic discs 204 could be bonded to the web 42 by a suitable adhesive.

The use of a ceramic material has the advantage that the apparatus is able to withstand higher temperatures compared to apparatus using UHMW PE.
25 In use, the device 200 operates in a similar manner to the device 100 of Figure 2.

By using a ceramic to ceramic rubbing surface, this does not have the temperature limitation of the UHMW PE.

Preferably the ceramic material is a very fine grained high

purity aluminium ceramic, typically about 99.9% pure. A ceramic material which is useful in the apparatus of the present invention is sold under the Trade Mark "ALSINT". A particularly suitable form of "ALSINT" is "ALSINT 99,7".

5 The total wattage dissipated by the device 200 is then a function of the heat radiation capacity of the gear box 64. In nearly all cases this limit would not be reached. The upper temperature limit of the oil is generally the limiting factor.

10 Slip does not occur between the discs 204 and the web 42. Further, the domed projections 219 reduce the contact area of the ceramic faces which increases pressure and squeezes out oil between the contacting faces more efficiently.

The oils used in conjunction with the apparatus of the
15 present invention is chosen more of its heat dissipating qualities than its lubricating quality. For this purpose synthetic oil has been found to have superior qualities compared with mineral oil. However, good lubrication qualities are required for the bearings and gears

20 associated with the apparatus of the present invention. A suitable synthetic oil is sold under the Trade Mark "SYNTHESO" and particularly suitable synthetic oils are "SYNTHESO HT 320" and "SYNTHESO D 460 EP".

The low friction material used in the apparatus of the
25 present invention typically has a coefficient of friction no more than 0.05 such as in the range from 0.03 to 0.05. The present invention provides a torque regulating device in which the problems of torque spikes upon start up are reduced. The present invention may easily be installed in

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a gearbox as shown and utilise the lubricating oil contained within the gearbox for cooling of the device. Modifications and variations such as would be apparent to a skilled address are deemed within the scope of the present invention. For example, the gear wheel 44 may be replaced by a V-belt pulley or similar pulley.

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CLAIMS

1. A torque regulating device characterised by a disc arranged to be fixedly attached to a shaft, friction material having a low coefficient of friction which remains substantially constant whether the friction material is dry or lubricated, a gear wheel means arranged to be mounted about the shaft, the friction material being disposed between the disc and the gear wheel means, and means being provided for clamping the friction material between the disc and the gear wheel means.
2. A torque regulating device according to claim 1, characterised in that there is provided spring means disposed between the disc and a pressure plate, the spring means bearing on the friction material to urge the friction material onto the gear wheel means.
3. A torque regulating device according to claim 2, characterised in that the spring means is in the form of one or more Belville spring washers.
4. A torque regulating device according to claim 3, characterised in that the disc has one or more spigots passing through the or each of the Belville spring washers.
5. A torque regulating device according to claim 4, characterised in that the pressure plate has apertures corresponding to the or each spigot, each spigot being slidably received in a corresponding one of the apertures.
6. A torque regulating device according to any one the preceding claims, characterised in that there is provided a further disc having a threaded sleeve which passes through the disc, a locknut to engage threadedly the threaded

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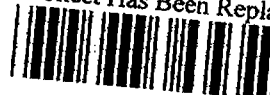


sleeve and to clamp the friction material against the gear wheel means

7. A torque regulating device according to claim 7, characterised in that there is provided a lockwasher
5 arranged to prevent rotation of the locknut relative to the threaded sleeve.
8. A torque regulating device according to claim 6 or 7, characterised in that the first mentioned disc is keyed to the threaded sleeve so that said first mentioned disc
10 rotates in unison with the further disc.
9. A torque regulating device according to any one of the preceding claims, characterised in that the friction material is in the form of an annular disc.
10. A torque regulating device according to claim 9,
15 characterised in that the or each annular disc of friction material has one or more radial grooves to allow passage of lubricating liquid.
11. A torque regulating device according to any one of claims 1 to 8, characterised in that the friction material
20 is in the form of a plurality of buttons.
12. A torque regulating device according to claim 11, characterised in that the buttons are received and held relative to each other in a button cage.
13. A torque regulating device according to claim 12,
25 characterised in that each button has circumferential flange and is received in a corresponding aperture in the button cage, the flanges of adjacent buttons being disposed on opposite sides of the button cage to prevent the button cage contacting the gear wheel means, the first mentioned



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disc or the further disc.

14. A torque regulating device according to claim 13,
characterised in that the button cage has a plurality of
peripheral open apertures configured such that a button
5 received in one of the open apertures extends past an outer
edge of the button cage to thereby centralise the button
cage within an annular recess relative to the gear wheel
means and to prevent the periphery of the button case from
contacting the gear wheel means.

10 15. A torque regulating device according to claim 11,
characterised in that each button is located in a
respective recess in the first mentioned disc or the
further disc.

16. A torque regulating device according to claim 15,
15 characterised in that the buttons are arranged to slide on
an annular disc of material whose coefficient of friction
remains substantially constant regardless of whether the
material is dry or lubricated, the annular disc of material
being disposed between the buttons and the gear wheel means
20 such that the annular disc of material is clampable between
the buttons and the gear wheel means.

17. A torque regulating device according to claim 16,
characterised in that the buttons have faces engaging the
annular disc which are formed with a plurality of
25 projections to increase the pressure applied to the annular
disc.

18. A torque regulating device according to claims 16 and
17, characterised in that the annular disc of material is
received and located in a corresponding annular recess in

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the gear wheel means.

19. A torque regulating device according to claim 18, characterised in that the annular disc of material is positively engaged by the gear wheel so as to prevent the annular disc rotating relative to the gear wheel.
20. A torque regulating device according to any one of the preceding claims, characterised in that the gear wheel means has one or more notches arranged to allow passage of the lubricating liquid therethrough to cool the friction material.
21. A torque regulating device according to any one of the preceding claims, characterised in that the material whose coefficient of friction remains substantially the same whether the material is dry or lubricated is an ultra high molecular weight polyethylene.
22. A torque regulating device according to claim 21, characterised in that the ultra high molecular weight polyethylene has a molecular weight between 3 million and 8 million.
23. A torque regulating device according to any one of claims 1 to 20, characterised in that the material whose coefficient of friction remains substantially the same whether the material is dry or lubricated is ceramic with the slipping faces ground to an extremely fine structure finish.
24. A torque regulating device according to claim 23, characterised in that the contacting faces are ground to an average surface roughness below about 55 microns.

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