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(54) IMPROVEMENTS IN OR RELATING TO SYNCHROMESH GEARBOXES

(71) We, LANCIA & C. FABBRICA AUTOMOBILI TORINO S.P.A., an Italian Joint Stock Company, of 27, Via Vincenzo Lancia, Turin, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to synchromesh gearboxes, and particularly to such gearboxes for use on automobiles.

In synchromesh gearboxes all the pairs of gear wheels are in constant mesh, with one gear wheel of each pair being fixed to one shaft for example the lay shaft, and the other gear wheel of the pair being freely rotatable on the main shaft: the various transmission ratios are selected by sliding different selector sleeves into position to connect a selected gear to the shaft on which it is freely rotatable. Before such connecting can take place, however, it is necessary to equalise the angular velocity of the freely rotatable gear wheel with respect to the shaft (generally the main shaft of the gearbox) for the purpose of facilitating connecting of the gear wheel to this shaft.

The present invention seeks to provide a synchromesh gearbox having an improved synchroniser arrangement and particularly relates to a gearbox of the type in which synchronisation of rotation of a gear wheel with a shaft on which it is freely rotatably carried is effected by means of a synchroniser arrangement, comprising: a synchroniser hub connected for rotation with the shaft and carrying an axially displaceable selector ring thereon, which selector ring has a radially inner toothed surface engaged with a radially outer toothed surface of the synchroniser hub; a synchroniser ring positioned to one side of the synchroniser hub and having a friction surface for engagement, upon axial displacement of the synchroniser ring, with a corresponding friction surface formed on the gear wheel to be synchronized or on an element carried thereby; the said synchroniser ring being provided with radially outwardly directed teeth for opposing, in known manner, axial displacement of the selector ring between the initial engagement of the said cooperating friction surfaces and the end of a synchronisation operation; a plurality of intermediate elements, each of which is housed in a radial recess in the periphery of the synchroniser hub and is urged radially outwardly by resilient biasing means, into engagement with the walls of an annular groove in the inner surface of the selector ring, and; means for causing a synchronisation operation, by effecting an axial displacement of the selector ring so that the intermediate elements are pressed against the facing surface of the synchroniser ring to cause engagement between the friction surface of the synchroniser ring and the friction surface of the gear wheel or element carried thereby; the axial displacement of the selector ring also causing, at the end of a synchronisation operation, engagement of a part of the toothed inner surface of the selector ring with a corresponding toothed surface on an element mounted for rotation with the gear wheel, the remaining part of the internal surface of the selector ring remaining in engagement with the outer surface of the synchroniser hub.

In gearboxes of this type, the action exerted by the intermediate elements in combination with the resilient biasing means is for the purpose of preventing, in the initial stage of synchronisation, the toothed inner surface of the selector ring from being able to come into direct contact with the outer teeth of the synchroniser ring; in this stage contact takes place, therefore, between the abovementioned intermediate elements, in the annular recess of the selector ring and the corresponding lateral surface of the synchroniser ring.

The synchroniser ring is then urged

towards the gear wheel to be synchronised so as to cause engagement of the respective friction surfaces; since generally the gear wheel will be rotating at a velocity different from that of the synchroniser hub and thus also, of the synchroniser ring; the contact between the friction surfaces causes a couple tending to reduce or eliminate this difference.

The synchroniser ring in gearboxes of this type, is carried on the synchroniser hub in such a manner as to be capable of a small angular displacements with respect to the hub. This angular displacement is such that at the ends of the movement, the outer teeth of the synchroniser ring are located in a staggered position with respect to the toothed inner surface of the selector ring so that engagement between said outer teeth of the synchroniser ring and said toothed inner surface of the selector ring is prevented. The synchroniser ring is located in this position in the initial stage of each synchronisation movement by the effect of the abovementioned couple due to the frictional engagement of the corresponding faces of the synchroniser ring and the gear to be synchronised or an element carried thereby.

The conformation of the outer surface of the intermediate elements and of the corresponding surface of the annular recess of the selector ring is such as to produce a radially inwardly directed thrust on the intermediate elements following application to the selector ring of an axial force. As the axial force upon the selector ring increases the intermediate elements are progressively moved radially inwardly against the action of the resilient biasing means. In this way the internal teeth of the selector ring are eventually brought into direct contact with the outer teeth of the synchroniser ring. By this time, however, the teeth of the synchroniser ring have been moved to a staggered position with respect to the teeth of the synchroniser hub (and therefore the teeth of the selector ring which are engaged therewith),

due to the couple transmitted by the gear to be synchronised. This inertia couple reduces gradually as the speeds become synchronised until eventually the axial force on the synchroniser ring is sufficient to cause the angular displacement of the synchroniser ring necessary to align the outer teeth thereof with the teeth of the selector ring permitting engagement between the teeth of the selector ring and cooperating teeth formed on the gear to be synchronised or the said element carried thereby, thus connecting the gear wheel and the shaft against further relative rotation.

In one known form of such a gearbox the intermediate elements are constituted by keys. Such an arrangement has disadvantages, however, because relative movement between the keys and any one other part of the synchroniser arrangement is a sliding movement which produces frictional forces. Such friction forces can be considerable and since they oppose the desired movements of the components of the gearbox, smooth operation thereof is deleteriously effected.

It has already been proposed to employ as intermediate elements, balls rather than keys. In such a case the sliding mentioned above, while not being entirely eliminated, is nevertheless greatly reduced since movement of the balls is mainly effected by rolling. However, this arrangement has the disadvantage that contact between the intermediate elements and any other part of the arrangement is a point contact: this type of contact, since it arises often under heavy loads, can cause local deformations and much wear and tear. This disadvantage makes itself felt particularly in contact between the intermediate elements and the facing surface of the synchroniser ring.

The technical problem of this invention is to provide a synchromesh gearbox of the general type discussed above, in which the disadvantages due to contact with high local forces between the intermediate elements and the corresponding facing parts of the synchroniser arrangement are substantially eliminated whilst nevertheless avoiding sliding movements in the regions of contact under load.

According to the present invention, therefore, there is provided a synchromesh gearbox of the type in which synchronisation of rotation of a gear wheel with a shaft on which it is freely rotatably carried is effected by means of a synchroniser arrangement, comprising: a synchroniser hub, connected for rotation with the shaft and carrying an axially displaceable selector ring thereon, which selector ring has a radially inner toothed surface engaged with a radially outer toothed surface of the synchroniser hub: a synchroniser ring positioned to one side of the synchroniser hub and having a friction surface for engagement, upon axial displacement of the synchroniser ring, with a corresponding friction surface formed on the gear wheel to be synchronised or on an element carried thereby; the said synchroniser ring being provided with radially outwardly directed teeth for opposing, in known manner, axial displacement of the selector ring during the period between the initial engagement of the said cooperating friction surfaces and the end of a synchronisation operation; a plurality of intermediate elements, each of which is housed in a radial recess in the periphery of the synchroniser hub and is urged radially outwardly by resilient biasing

means, into engagement with the walls of an annular groove in the inner surface of the selector ring, and; means for causing a synchronisation operation by effecting an axial displacement of the selector ring so that the intermediate elements are pressed against the facing surface of the synchroniser ring to cause engagement between the friction surface of the synchroniser ring and the friction surface of the gear wheel or element carried thereby; the axial displacement of the selector ring also causing, at the end of a synchronisation operation, engagement of a part of the toothed inner surface of the selector ring with corresponding toothed surface on an element mounted for rotation with the gear wheel, the remaining part of the internal surface of the selector ring remaining in engagement with the outer surface of the synchroniser hub, in which the intermediate elements are constituted by rollers the axes of which are arranged perpendicularly to the driving shaft of the gearbox.

One embodiment of the invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is an exploded perspective view of a part of a synchromesh gearbox formed in accordance with the invention;

Figure 2 is an exploded perspective view of a part of the arrangement shown in Figure 1;

Figure 3 and Figure 4 are diagrammatic developed views, on larger scale, of a part of the arrangement of Figure 1 showing the component parts in two different operating positions during a synchronisation operation;

Figure 5 is an axial section of a part of the arrangement shown in Figure 1, and

Figure 6 is a partial cross section of the arrangement of Figure 5, taken on the line VI—VI of Figure 5.

In the drawings there is shown a shaft 1 on which is freely rotatably mounted a gear wheel 27. The shaft 1 is, in this embodiment, the main shaft, that is the driven shaft, of the gearbox. On the shaft 1 is mounted a synchroniser hub 2 torsionally connected to the shaft 1 by a splined coupling 3 (see Figure 5). The hub 2 comprises a sleeve 2*b* which has an internal splined section forming part of the splined coupling 3, a radially outwardly projecting annular ridge 2*a* extending from the sleeve 2*b* at a point mid way along the length of the sleeve 2*b*, a radial annular web 4 projecting outwardly from the ridge 2*a* and an annular flange 5, formed on its outer surface with teeth 6, at the periphery of the web 4. The web 4 and the axial flange 5 have three channels 7 in the form of radial slots spaced equi-angularly about the hub 2. The annular ridge 2*a* has three radial recesses 8 aligned with the three channels 7. Each recess 8 houses a helical spring 9 within which can slide a coaxial pin 10 having an enlarged head 11 forming a support plate at the radially outer end thereof, which support plate supports externally a roller 12; the axes of the three rollers 12 are located in a common plane transverse the axis of the shaft 1, and the axis of each roller 12 is perpendicular to a radial line passing through itself and the center line of the shaft 1. The head 11 of the pin 10 engages the radially outer end of the spring 9 and is resiliently biased thereby in a radially outward direction. A selector sleeve 13 having teeth 14 on the radially inner surface thereof engages the corresponding teeth 6 of the axial flange 5 of the selector hub 2. The inner surface of the selector sleeve 13 is, moreover, provided with an annular groove 15, having in V-shape axial section. The groove 15 receives the rollers 12 which are pressed radially outwardly by the action of the springs 9. On each side of the axial flange 5 of the synchroniser hub 2 is arranged a respective synchroniser ring 31 each having a conical internal surface 20 and an outer surface with a cylindrical section 18/having a toothed radial flange 16 at one end thereof, upon assembly synchroniser rings 31 are positioned with cylindrical section 18 of the outer surfaces engaged under the internal surfaces of the axial flange 5 of the synchroniser hub 2 whilst the radial flange 16 engages the corresponding end of the axial flange 5. The teeth of the radial flange 16 are indicated 17.

From the cylindrical section 18 of the outer surface of the synchroniser rings 31 extend three radial projections 19 which, upon assembly, are lodged in respective channels 7 of the axial flange 5 of the synchroniser hub 2. As seen from Figure 3, the projections 19 are narrower, circumferentially, an the channels 7 the ratio between the circumferential width of the channels 7 to the width of the projections 19 being such as to enable angular displacement of each synchroniser hub 2; the angle through which the rings 31 can turn with respect to the hub 2 is limited and is such that at the end points of this angular displacement the teeth 17 of the flange 16 are staggered with respect to the corresponding outer teeth 6 of the axial flange 5 of the synchroniser hub 2. At these end points, therefore, the teeth 6 and the teeth 17 are not aligned.

At the side of each synchroniser ring 31 is placed an associated annular synchroniser cone 21, the radially inner surface of which is formed with teeth 25 and the outer surface of which is constituted by a conical section 22 delimited by a radially outwardly projecting flange 23. The conical surface

22, in operation of the synchroniser arrangement, engage the corresponding conical inner surface 20 of the associated synchroniser ring 31 thus forming a conical friction coupling. The flange 23 has a plurality of radial teeth 24. In the embodiment illustrated in the drawings there are shown two gears 27*a* and 27*b* one placed to the left and the other to the right (with reference to Figure 5) of the selector sleeve 13. The gears 27*a*, 27*b* are freely rotatable on the synchroniser hub 2 and are each placed facing the corresponding synchroniser cone 21. The gear 27*a* has a radial flange 28*a* spaced from the body of the gear 27*a* and facing the radial flange 23 of the synchroniser cone 21. From the radial flange 28*a* projects an axially extending cylindrical body 29*a* on the outer surface of which are formed teeth 26*a* which engage, on assembly, with the internal teeth 25 of the corresponding synchroniser cone 21. Similarly, the gear 27*b* is provided wih a flange 28*b*, which for the sake of convenience is toothed, and a cylindrical body 29*b* projecting axially and having teeth 26*b* on its outer surface, which teeth engage the internal teeth 25 of the corresponding synchroniser cone 21. The selector ring 13 has on its radially outer surface an annular groove 30 in which is lodged a selector fork (not shown). Axial movement of the selector fork causes the selection of the desired transmission ratio by engaging the transmission gear 27*a* or 27*b* with the shaft 1, following a synchronisation of the speeds thereof according to whether the selector ring 13 is moved, with reference to Figure 5, to the left or to the right respectively.

Assuming that the selector ring 13 be moved to the left, coupling of the transmission gear 27*a* to the shaft 1 occurs in the following manner; At first the rollers 12 are drawn to the left by the selector ring 13 until they abut the projections 19 housed in the channel 7 and appertaining to the related synchroniser ring 31. Continuing the movement of the selector ring 13 to the left, the synchroniser ring 31 by the engagement of the rollers 12, is moved also the left until causing engagement of the cooperating conical friction surfaces 20 and 22. Since the gear 27*a* and with it the synchroniser cone 21 rotates normally at a speed different from that of the shaft 1 and thus also from synchroniser hub 2 and the related synchroniser ring 31, the friction between the conical contact surfaces 20 and 22 produces rotary movement of the synchroniser ring 31 with respect to the axial flange 5 of the hub 2 until the projections 19 are brought into contact with one or the other of the two lateral faces of the corresponding channel 7. In such a position the teeth 14 on the inside surface of the selector ring 13 are in a non-aligned position with respect to the teeth 17 of the synchroniser ring 31 and therefore, further axial movement of the collar 13, if not entirely prevented, is greatly hampered. At the same time the gear 27*a*, due to the friction on the conical surface 22 of the synchroniser cone 21, is accelerated or braked, tending to acquire a speed of rotation equal to that of the shaft 1 and the flange 5. As the difference in the speed of rotation of the gear 27*a* and the axial flange 5 decreases there is a progressive reduction of the forces causing the friction couple between the conical friction surfaces 20 and 22; therefore there is reduction of the couple keeping the teeth 19 in contact with the lateral surfaces of the corresponding channel 7 and thus the teeth 14 of the collar 13 can, by acting upon the corresponding teeth 17 of the synchroniser ring 31, produce small angular displacement of the synchroniser ring 31 necessary to enable further movement of the selector ring 13 to the left. The internal toothed surface 14 of the select ring 13 can then enter into engagement with the teeth 24 of the left-hand synchroniser ring 31 and also with the teeth of the left-hand synchroniser cone 21 (since by now the relative rotation is very slow or has ceased altogether) thereby rigidly connecting, for rotation together, the synchroniser cone 21, and thus also the gear 27*a*, to the flange 5. In this way the gear 27*a* becomes connected torsionally to the shaft 1.

WHAT WE CLAIM IS:—

1. A synchromesh gearbox of the type in which synchronisation of rotation of a gear wheel with a shaft on which it is freely carried is effected by means of a synchroniser arrangement, comprising:

a) a synchroniser hub connected for rotation with the shaft and carrying an axially displaceable selector ring thereon, which selector ring has a radially inner toothed surface engaged with a radially outer toothed surface of the synchroniser hub,

b) a synchroniser ring positioned to one side of the synchroniser hub and having a friction surface for engagement, upon axial displacement of the synchroniser ring, with a corresponding friction surface formed on the gear wheel to be synchronised or on an element carried thereby; the said synchroniser ring being provided with radially outwardly directed teeth for opposing, in known manner, axial displacement of the selector ring during the period between the initial engagement of the said cooperating friction surfaces and the end of a synchronisation operation,

c) a plurality of intermediate elements, each of which is housed in a radial recess in the periphery of the synchroniser hub and is

urged radially outwardly by resilient biasing means, into engagement with the walls of an annular groove in the inner surface of the selector ring, and

d) means for causing a synchronisation operation by effecting an axial displacement of the selector ring so that the intermediate elements are pressed against the facing surface of the synchroniser ring to cause engagement between the friction surface of the synchroniser ring and the friction surface of the gear wheel or element carried thereby; the axial displacement of the selector ring also causing, at the end of a synchronisation operation, engagement of a part of the toothed inner surface of the selector ring with corresponding toothed surface on an element mounted for rotation with the gear wheel, the remaining part of the internal surface of the selector ring remaining in engagement with the outer surface of the synchroniser hub, in which the intermediate elements are constituted by rollers the axes of which are arranged perpendicularly to the driving shaft of the gearbox.

2. A synchromesh gearbox as claimed in Claim 1 in which the axes of the rollers are located in a common plane.

3. A synchromesh gearbox as claimed in Claim 2 in which the rollers are equi-angularly spaced from each other around the hub.

4. A synchromesh gearbox substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

Fig. 1

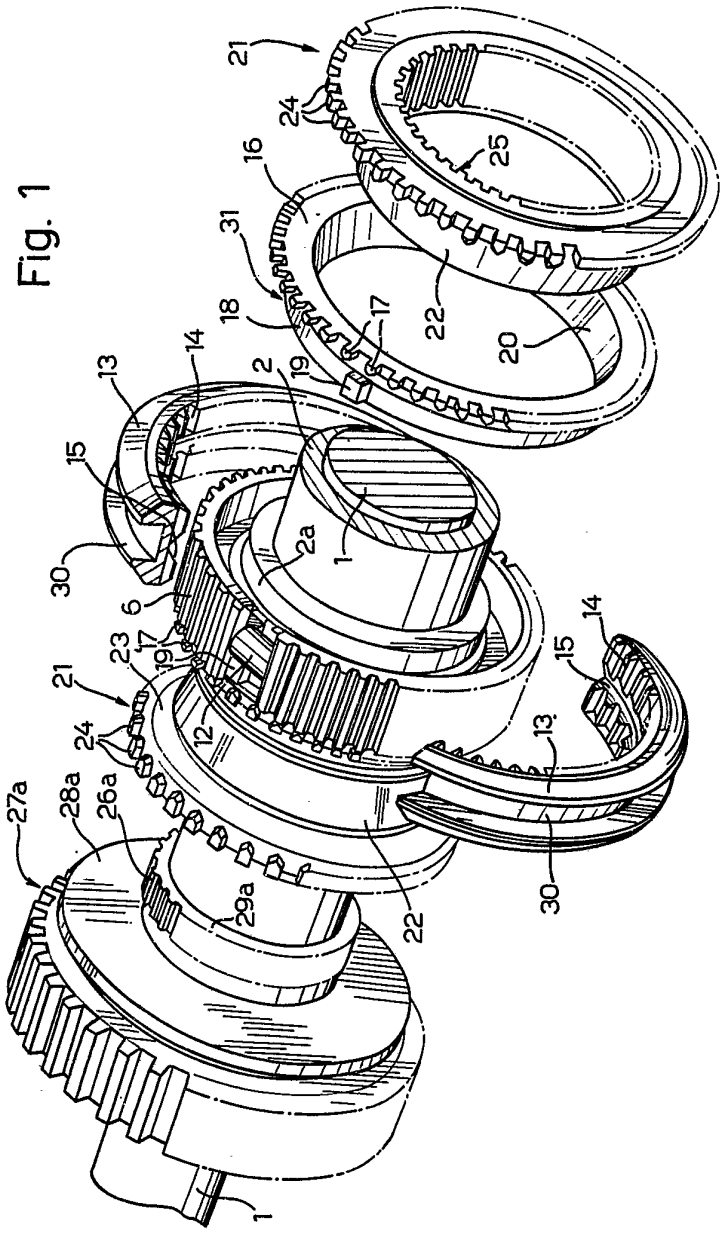

Fig. 2

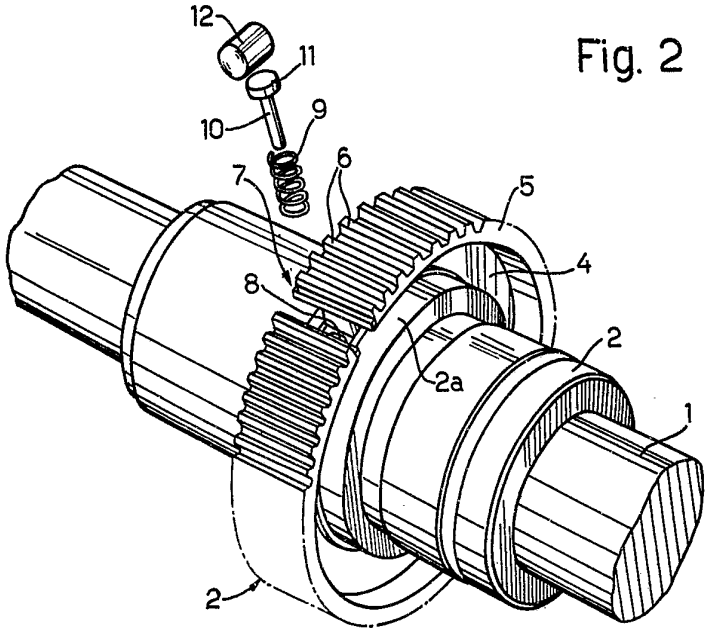

Fig. 3

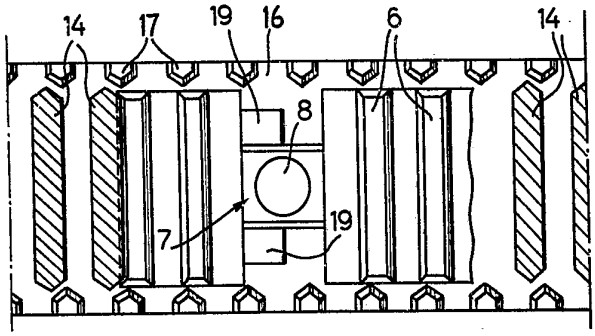

Fig. 5

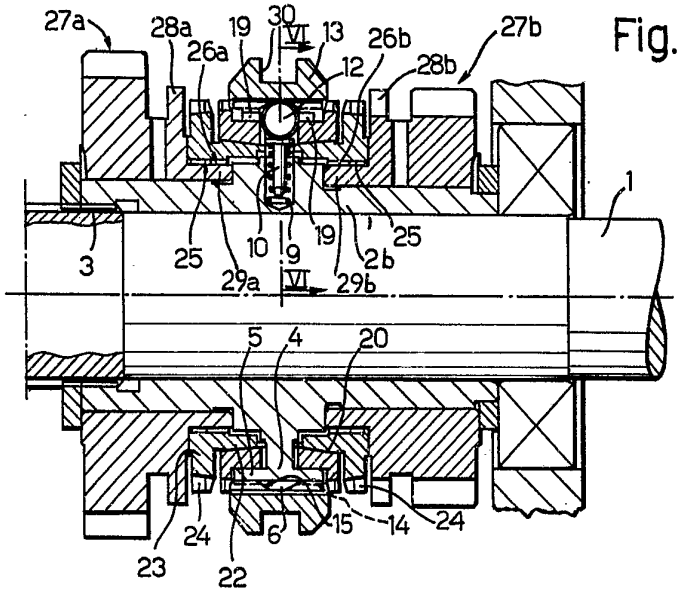

Fig. 6

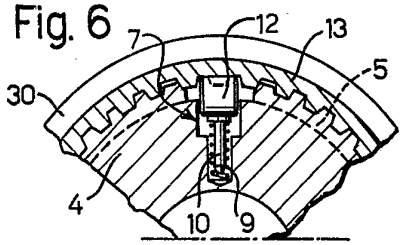

Fig. 4