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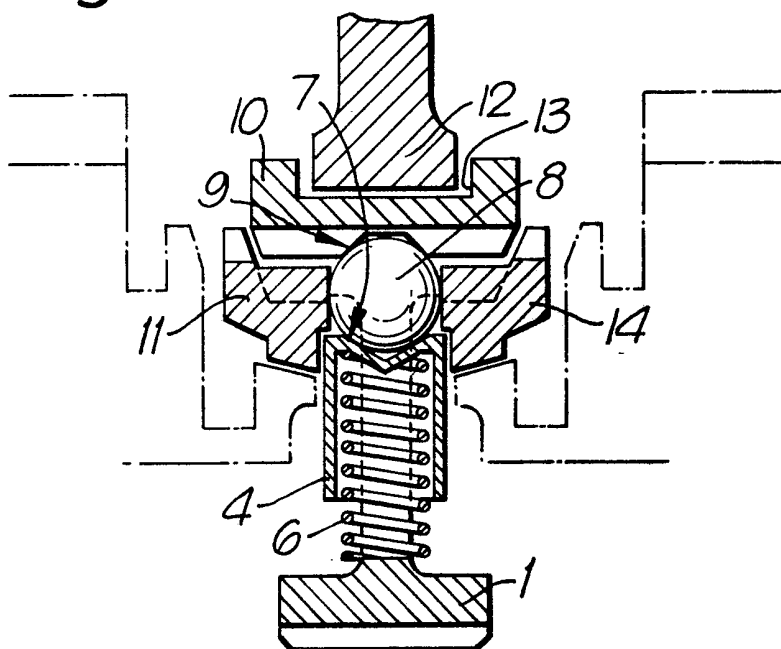
J N B Breakwell

(54) **Transmission and synchro-
nizer**

(57) A transmission and synchro-
nizer applicable to a motor vehicle
countershaft-type gearbox including
constant-mesh gear pairs for a plu-
rality of forward ratios includes a
sleeve clutch 10 which is slidably
mounted by means of spline teeth
on a hub of a rotary shaft. The
clutch includes a generally V-sec-
tion detent groove 9. A plurality of
circumferentially spaced radial slots
in the hub accommodate respective
plungers 4, each of which is spring-
loaded in a direction radially out-
wardly of the hub and has an end
surface formed with a relatively
shallow-angle detent recess 7. A
detent member 8 (ball or roller) is
seated in each detent recess and is
located in the detent groove. On
axial movement of the clutch the

detent members transmit an ener-
gising force to an adjacent synchro-
nizer ring 11. The detent recess in
the end surface of each plunger
provides for resilient centring of the
detent member and the clutch rela-
tive to the hub.

Fig. 3.



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Fig. 1.

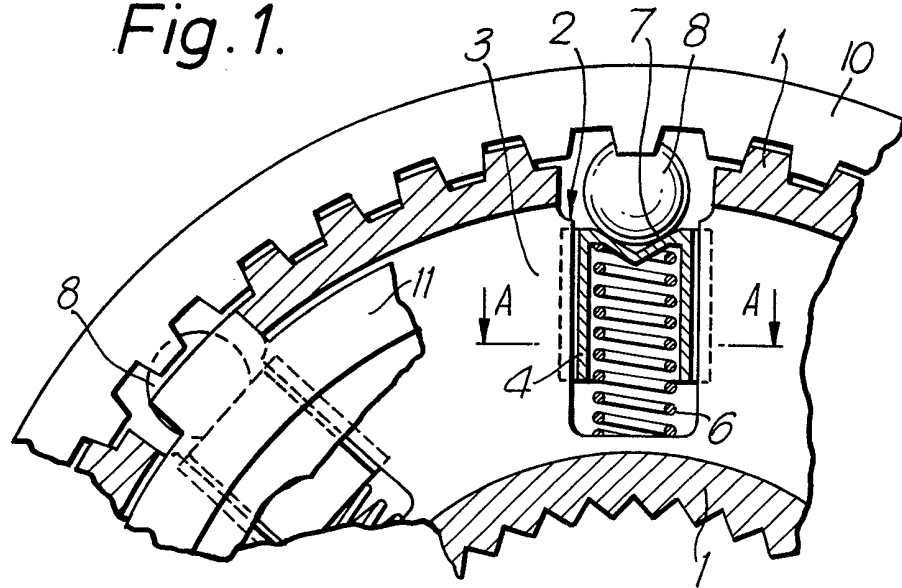


Fig. 2.

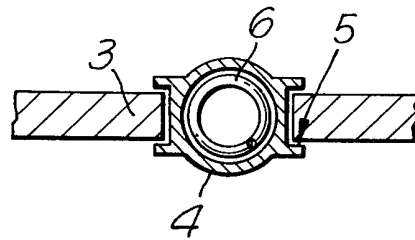


Fig. 3.

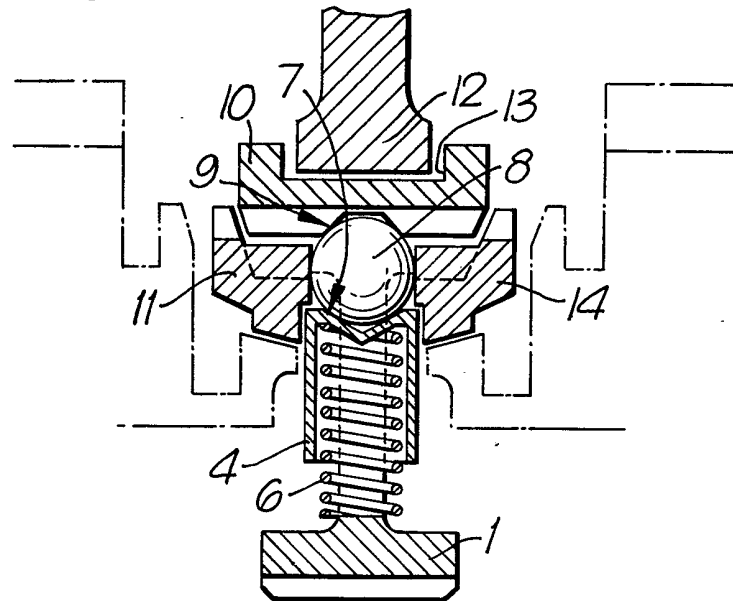


Fig. 4.

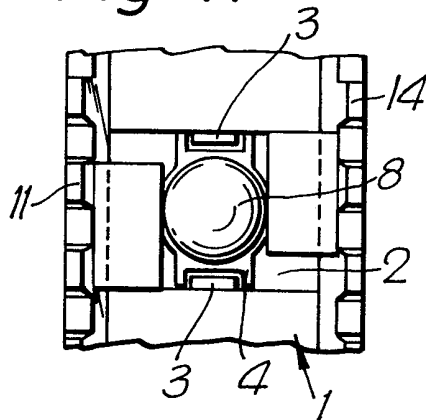
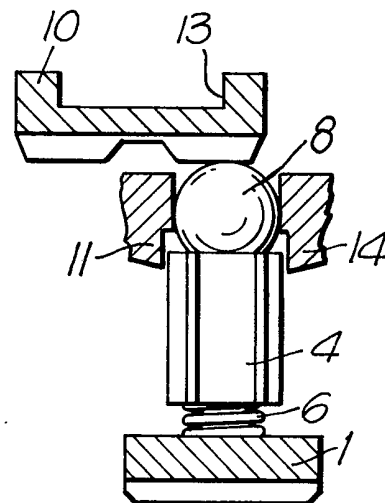


Fig. 5.



SPECIFICATION

Transmission and synchronizer

5 The invention is particularly concerned with a transmission and synchronizer applicable to a motor vehicle countershaft-type gearbox including constant-mesh gear pairs for a plurality of forward ratios.

10 Paper No. 680 008 of the Society of Automotive Engineers, entitled "Manual Transmission Synchronizers", by Richard J. Socin and L. Kirk Walters, delivered at the Automotive Engineering Congress, Detroit, Michigan, January 8-12 1968, describes some types of synchronizers and their method of operation. *Inter alia*, so-called constant load cone synchronizers, and strut-type (key-type) blocking synchronizers, are described.

20 A transmission and synchronizer in accordance with the present invention comprises a rotary drive element, a rotary shaft having a hub, a sleeve clutch which is mounted to rotate with the hub and to be selectively axially slidable relative thereto into positive-clutch engagement with the rotary drive element to establish a positive-clutch drive connection between the rotary drive element and the rotary shaft, a synchronizer ring which is formed with a frustoconical friction surface and is arranged to rotate with the hub, a corresponding frustoconical friction surface formed on the rotary drive element or on part that rotates with the drive element, radially inwardly facing detent groove in the clutch, at least one plunger which is movably mounted on the hub and is spring-loaded in a direction radially outwardly of the hub and has an end surface formed with a detent recess, and at least one detent member, in the form of a ball or roller, which is seated in the detent recess of a respective spring-loaded plunger as aforesaid and is resiliently biased by the plunger towards a position of engagement with the detent groove in the clutch, the configuration and relative disposition of the parts being such that, from a centred position of the clutch in which the detent member is seated in the detent recess and is located in the detent groove of the clutch, in an initial increment of movement of the clutch in a direction towards the rotary drive element the detent member is entrained by the detent groove of the clutch for movement relative to the plunger in the said axial direction to move the synchronizer ring into a position establishing a condition of torque-transmitting frictional interengagement of the frustoconical friction surfaces, for synchronization of the rotary speeds of the drive element and the shaft, and in a subsequent increment of movement of the clutch the detent member progressively rides out of the detent groove of the clutch, and the clutch establishes a positive-clutch drive connection as aforesaid between the

rotary drive element and the shaft.

Thereby, with a potentially relatively simple construction the detent member acts as a centralizing means for the sleeve clutch and also provides a means of transmitting an energizing force to the synchronizer ring for effecting torque-transmitting frictional interengagement of the frustoconical surfaces.

A ball or roller represents an advantageous form of detent member, inasmuch as accurate dimensions and finish can be obtained consistently and relatively cheaply.

The detent recess in the end surface of the respective plunger may be of concave or V-section form. If the detent member is a roller, the detent recess will preferably have a constant cross-sectional shape along the length of the cylindrical surface of the roller. In the detent member is a ball, it can be advantageous for the detent recess to be a shallow circular recess (of conical or concave configuration), to provide a centring action for the ball in a direction circumferentially of the hub, and so avoid the need to provide a close locating fit between the ball and adjacent surfaces of a slot provided in the hub for accommodating the ball.

The plunger is conveniently of hollow cylindrical form, with its spring constituted by a helical compression spring contained within the hollow interior of the plunger and seated at one end on the hub of the rotary shaft. The spring is thereby protected by the plunger, and the end which is seated on the hub may be located by a short portion of the hub projecting into the interior of the spring. With such a hollow cylindrical configuration of the plunger, also, the plunger may be formed with opposed grooves which co-operate with adjacent parts of a web portion of the hub for guiding the plunger for the required movement in a direction radially of the hub whilst locating it in an axial direction.

With the respective detent member accommodated in a radial slot of the hub, rotation of the synchronizer ring conjointly with the hub may be achieved by having a lug of the synchronizer ring extending into the radial slot, and the detent member can be arranged to abut an end surface of the lug for transmitting the energizing force to effect the axial movement of the synchronizer ring for torque-transmitting frictional interengagement of the frustoconical surfaces.

A transmission and synchronizer in conformity with the present invention can be constructed as the so-called constant load type of synchronizer not having specific provision for blocking the final increment of movement of the clutch into its positive-engagement position other than the detent action of the detent groove in the clutch. Alternatively, however, the baulk ring (blocker ring) type of construction may be used in which the sleeve clutch and the hub are formed with co-operating

axially extending spline teeth by means of which the clutch is slidably mounted on the hub, the synchronizer ring is formed with a ring of external teeth provided with baulk chamfers for engagement by chamfered end portions of the spline teeth of the clutch sleeve during synchronization of the rotary speeds of the drive element and of the shaft, and the rotary drive element is formed with a ring of external teeth for engagement by the spline teeth of the clutch to establish the positive-clutch drive connection between the rotary drive element and the shaft.

Particularly as applied to a motor vehicle counter-shaft-type gearbox, a transmission and synchronizer in conformity with the present invention may utilize a double-acting sleeve clutch type of construction in which a second rotary drive element is disposed on the opposite axial side of the hub to the drive element already mentioned (first drive element), and a second synchronizer ring is disposed between the second drive element and the hub and, by movement of the clutch sleeve in the opposite direction to that for coupling with the first drive element, is selectively engageable by the detent member for providing synchronization for positive-clutch engagement of the sleeve clutch with the second drive element.

In the context of a motor vehicle counter-shaft-type gearbox, one or both of the rotary drive elements will normally comprise a gear-wheel that is rotatably mounted on the rotary shaft (the gearbox mainshaft) and is in constant mesh with a respective driven counter-shaft gear. For a direct-drive ratio, the rotary drive element may comprise an input gear (driven by a plate clutch output shaft) of a pair of meshing head gears transmitting drive to the gearbox countershaft.

A transmission and synchronizer in conformity with the present invention is usable in a passenger vehicle or a commercial type of vehicle

In the accompanying drawing:—

Figure 1 is a fragmentary front elevation, with some parts in section, showing a hub and sleeve clutch, with spring-loaded plunger and detent ball, of one embodiment of a transmission and synchronizer in accordance with the present invention;

Figure 2 is a fragmentary section, on the line A—A of Fig. 1, in the direction of the arrows, through the plunger and a web portion of the hub, illustrating the guiding of the plunger;

Figure 3 is a fragmentary side elevation, with some parts in section, of the embodiment of the transmission and synchroniser shown in Figure 1;

Figure 4 is a fragmentary plan (circumferential view) illustrating the co-operation between the detent ball and a pair of projecting lugs on respective synchronizer rings in the Fig. 1 embodiment; and

Figure 5 is a fragmentary side elevation basically similar to Fig. 3 but showing the sleeve clutch displaced into a positive-engagement position.

As is shown in the drawing, an embodiment of a transmission and synchronizer in accordance with the present invention includes an annular clutch hub 1 which is mounted by means of internal splines on a rotary shaft (not shown) constituting the mainshaft of a countershaft-type gearbox for a motor vehicle. In a conventional manner not shown, a vehicle engine is connected to drive an input member of a plate clutch, and an output member of the clutch is connected by way of a clutch output shaft to drive an input gear of a pair of head gears in the gearbox, this input gear meshing with an output gear driving a rotary countershaft gear cluster. A plurality of gearwheels, two of which, disposed on opposite axial sides of the hub 1, are indicated in interrupted lines in Fig. 3, for respective forward gear ratios are rotatably mounted on the gearbox mainshaft and are in constant mesh with respective gears of the driven countershaft gear cluster.

The clutch hub 1 is provided with a plurality of circumferentially spaced radial slots 2, which extend into a web 3 of the hub, as is shown in Fig. 1. In each slot, a hollow cylindrical plunger 4 is movably mounted on the hub, with pairs of longitudinal external ribs on the plunger forming opposed grooves 5 which co-operate with the web of the hub, as is shown in Fig. 2, to guide the plunger for movement in a direction radially of the hub, and to conveniently locate the plunger about its own axis. A helical compression spring 6 is contained within the hollow interior of the plunger and is seated at its radially inner end on the hub, with a short projecting portion of the hub extending into the interior of the spring to provide some location for the spring end. The other end of the spring 6 is seated on a closed end of the plunger, and the spring provides spring loading for resiliently biasing the plunger in a direction radially outwardly of the hub.

The closed end of the spring-loaded plunger 4 is formed to provide a shallow conical recess 7 in an end surface of the plunger facing in a direction radially outwardly of the hub. A detent ball 8 is seated in the detent recess 7, and is biased in a direction radially outwardly of the hub by spring-loaded plunger 4.

In the relative position of the parts which is shown in Fig. 3, the detent ball 8 is thereby spring-urged into locating engagement with a generally V-section, radially inwardly facing detent groove 9 in a sleeve clutch 10 (engagement clutch) that is slidably mounted on the hub 1 by a splined connection (shown in Fig. 1), which constrains the clutch to rotate conjointly with the hub. The detent groove 9

in the clutch 10 has a steeper detent angle than the detent recess 7 in the plunger 4.

The seating of the detent ball 8 in the conical detent recess 7 in the plunger 4 tends to maintain the ball resiliently centred relative to the web of the hub and the plunger, and thus centred in both the axial direction and the circumferential direction of the hub. Because of the engagement of the detent ball in the generally V-shaped detent groove 9 in the clutch 10, as illustrated in Fig. 1, the detent ball thereby tends to maintain the clutch resiliently centred in the axial direction, corresponding to a neutral position of the clutch. The centring of the detent ball in the circumferential direction of the hub by the circular detent recess in the plunger avoids the need for a close locating fit between the detent ball and the walls of the slot in the hub, as is illustrated in Fig. 4, in which a clearance is shown between the detent ball and each of the facing walls of the slot in the hub.

For effecting selective axial movement of the sleeve clutch 10, a conventional shift fork (striker fork) 12, manually actuable by way of a conventional selector mechanism (not shown), co-operates with a circumferential groove 13 in the clutch 10. As is illustrated in Fig. 3, there is clearance, in the direction axially of the hub, between the shift fork 12 and the walls of the circumferential groove 13: the clearance allows the detent ball to effect centring of the clutch in its neutral position without interference from the selector mechanism. Centring of the clutch by the detent ball, in co-operation with the detent recess in the spring-loaded plunger, is inherently more accurate than would be the case if centring were effected by the fork and selector mechanism, inasmuch as dimensional tolerances in the selector mechanism could be expected to result in inaccurate centring if the fork were used for centring.

First and second synchronizer rings 11 and 14 are disposed on opposite axial sides of the web 3 of the clutch hub, and, as is illustrated in Fig. 4, are formed with lugs which extend into the radial slots 2 in the clutch hub with circumferential clearance. The lugs of each synchronizer ring form a means whereby the ring is constrained to rotate with the clutch hub, but is capable of limited circumferential movement relative to the hub. In each of the radial slots 2 the end surfaces of the lugs of the synchronizer rings are disposed adjacent the detent ball, on opposite sides of the detent ball, in a position such that movement of the detent ball in either axial direction from its centred position transmits an axially directed force by way of the respective lug to the corresponding synchronizer ring.

Each of the synchronizer rings 11 and 14 is formed with a ring of external teeth provided with conventional baulk chamfers (blocker

chamfers) as illustrated in Fig. 4. The splined connection between the sleeve clutch 10 and the clutch hub 1 includes internal spline teeth on the clutch 10 which in conventional manner include chamfered end portions for co-operation with the baulk chamfers on the respective synchronizer ring.

Each of the synchronizer rings 11 and 14 is further formed with a frustoconical friction surface for engagement with a corresponding friction surface on the respective constant-mesh gearwheel. In the neutral position shown in Fig. 3, there is a small clearance between each pair of friction surfaces. Each gearwheel is provided with a conventional ring of external teeth for engagement by the internal spline teeth of the clutch to establish a positive-clutch drive connection between the gearwheel and the mainshaft.

The operation of the transmission and synchronizer is as follows.

In a neutral condition of the selector mechanism, the various parts of the transmission and synchronizer are in the relative positions illustrated in Fig. 3. The detent ball 8 is seated in the detent recess 7 in the plunger 4, and is resiliently biased by the spring loading of the plunger into a fully seated position in the central detent groove 9 in the sleeve clutch 10. Thereby, both the detent ball and the clutch are retained in a centred position relative to the plunger and the web 3 of the hub.

On actuation of the selector mechanism for movement of the shift fork to the left as viewed in Fig. 3, the shift fork initially takes up the clearance between itself and the left-hand wall of the circumferential groove in the sleeve clutch 10, and thereupon applies to the sleeve clutch a leftward force which is transmitted by way of a wall of the detent groove 9 to the detent ball 8. Since the detent groove 9 in the sleeve clutch 10 has a steeper detent angle than the detent recess 7 in the plunger 4, the resulting initial displacement of the detent ball to the left takes place with the detent ball remaining fully engaged in the detent groove in the clutch, but involves breaking the detent effect of the detent recess in the plunger. That is to say, the displacement of the detent ball to the left provides a camming action on the wall of the relatively shallow-angle conical detent recess 7 which depresses the plunger 4 somewhat, in opposition to its spring loading. During its leftward displacement the detent ball 8 acts by way of the end surface of the respective lug of the synchronizer ring 11 to apply an energizing force to the synchronizer ring and so cause the synchronizer ring to move axially to take up the clearance between the frustoconical friction surfaces and establish a condition of torque-transmitting frictional interengagement of the frustoconical friction surfaces.

With the friction surfaces in interengage-

ment, no further axial displacement of the synchronizer ring 11, and hence of the detent ball 8, can take place. Subsequent axial displacement of the sleeve clutch is therefore

possible only by breaking the detent effect of the detent groove 9 in the clutch, that is to say the detent ball 8 must begin to ride out of the detent groove 9, in opposition to the spring loading of the plunger, and thereby providing an increase in energizing force.

However, the interengagement of the frustoconical friction surfaces induced by the energizing force will have produced an indexing torque causing circumferential displacement of the synchronizer ring 11 relative to the sleeve clutch 10 until the lugs of the synchronizer ring engage the respective wall of each radial slot 2 in the clutch hub 1, such that the baulk chamfers of the external teeth on the synchronizer ring are thereby brought into axial alignment with the chamfered end portions of the internal spline teeth of the hub, and the axial displacement of the sleeve clutch will accordingly cause the chamfered end portions of the spline teeth to engage the baulk chamfers. In this condition, further axial displacement of the clutch sleeve is blocked, and the effort applied by way of the shift fork becomes effective at the interengaged frustoconical friction surfaces as a synchronizing drag torque tending to bring the mainshaft and the left-hand rotary gearwheel into rotary synchronism.

Only when the mainshaft and the rotary gearwheel approach rotary synchronism does the effort applied by way of the shift fork result in a camming action causing the synchronizer ring 11 to move circumferentially relative to the sleeve clutch sufficiently to allow the internal spline teeth to pass between the blocker teeth, and so permit the sleeve clutch to move into a position of positive-clutch engagement with the external teeth on the left-hand rotary gearwheel, so coupling together the rotary gearwheel and the mainshaft to cause the mainshaft to be driven at the speed of the rotary gearwheel.

This positive-clutch engagement condition is illustrated in Fig. 5. The detent ball 8 has fully depressed the plunger 4, having ridden out of the detent groove 9 and on to the crest of a spline tooth when the chamfered end portions of the internal spline teeth moved past the baulk chamfers, so allowing further movement of the sleeve clutch into the positive-engagement position. However, in this positive-clutch engagement condition the detent ball 8 remains seated in the detent recess 7 in the spring-loaded plunger 4, and is thereby maintained resiliently centred. This resilient centring of the detent ball by the detent recess in the plunger in the fully-engaged condition avoids interference of the detent ball and the synchronizer ring 11, so avoiding any interplay between the detent ball

and the synchronizer ring 11 which might tend to seat the synchronizer ring on its cone surface and thereby cause malfunction or excessive wear, and allows the two synchronizer rings 11 and 14 to float independently, without any likelihood of interaction (interplay) by way of the detent ball. In other words, there is no likelihood of malfunction due to one synchronizer ring wrongly applying a push to the other.

Synchronized positive-clutch engagement by way of the second synchronizer ring 14 takes place in a manner corresponding to that described in relation to the first synchronizer ring 11.

In the embodiment described, the detent balls comprise ordinary commercial ball bearings, which have proved to have a very satisfactory dimensional accuracy and surface finish at an economic cost.

In one actual heavy-duty arrangement conforming to the embodiment described, the sleeve clutch moves about 50 thou (1.27 mm) from its neutral position to contact the baulk chamfers.

The relative degree of the centralizing detent effect and the synchronizer energizing effect may be determined as follows:

Let α_1 = Detent angle of detent recess in plunger.

α_2 = Detent angle of detent groove in engagement clutch (sleeve clutch).

μ = Coefficient of friction at the contact points on the detent ball.

P = Load acting on the plunger.

Axial load to break detent and move engagement clutch from the central (neutral) position = $P (\cot \alpha_1 + \mu)$.

Axial load to break detent and energize synchro cone
= $P (\cot \alpha_2 - \cot \alpha_1 + \mu / \sin^2 \alpha_2)$

From the foregoing it will be evident that the present invention involves a transmission synchronizer in which a detent member is seated in a detent recess in a resiliently biased member and is resiliently engaged in a detent groove of a sleeve clutch, and axial movement of the clutch towards a positive-engagement position causes the detent member initially to apply an energizing force to a rotary synchronizer member.

The present invention includes within its scope the subject-matter of the claims which follow, but is not necessarily limited to this subject-matter.

The present invention includes within its scope the subject-matter of the claims which follow, but is not necessarily limited to this subject-matter.

CLAIMS

1. A transmission and synchronizer, comprising a rotary drive element, a rotary shaft having a hub, a sleeve clutch which is mounted to rotate with the hub and to be

selectively axially slidable relative thereto into positive-clutch engagement with the rotary drive element to establish a positive-clutch drive connection between the rotary drive element and the rotary shaft, a synchronizer ring which is formed with a frustoconical friction surface and is arranged to rotate with the hub, a corresponding frustoconical friction surface formed on the rotary drive element or on a part that rotates with the drive element, a radially inwardly facing detent groove in the clutch, at least one plunger which is movably mounted on the hub and is spring-loaded in a direction radially outwardly of the hub and has an end surface formed with a detent recess, and at least one detent member, in the form of a ball or roller, which is seated in the detent recess of a respective spring-loaded plunger as aforesaid and is resiliently biased by the plunger towards a position of engagement with the detent groove in the clutch, the configuration and relative disposition of the parts being such that, from a centred position of the clutch in which the detent member is seated in the detent recess and is located in the detent groove of the clutch, in an initial increment of movement of the clutch in a direction towards the rotary drive element the detent member is entrained by the detent groove of the clutch for movement relative to the plunger in the said axial direction to move the synchronizer ring into a position establishing a condition of torque-transmitting frictional interengagement of the frustoconical friction surfaces, for synchronization of the rotary speeds of the drive element and the shaft, and in a subsequent increment of movement of the clutch the detent member progressively rides out of the detent groove of the clutch, and the clutch establishes a positive-clutch drive connection as aforesaid between the rotary drive element and the shaft.

2. A transmission and synchronizer according to claim 1, in which the detent recess in the end surface of the plunger is of shallow V-shaped configuration and the detent groove in the clutch is of generally V-shaped configuration having a steeper detent angle than the detent recess in the plunger.

3. A transmission and synchronizer according to claim 1, in which the detent member comprises a ball, the detent recess in the plunger is a shallow circular recess, and the detent groove in the clutch is of generally V-shaped configuration having a steeper detent angle than the detent recess in the plunger.

4. A transmission and synchronizer according to any one of claims 1 to 3, in which the plunger is of hollow cylindrical form and the spring thereof comprises a helical compression spring contained within the hollow interior of the plunger and seated at one end on the hub of the rotary shaft.

5. A transmission and synchronizer according to any one of claims 1 to 4, in which

the plunger is disposed in a radial slot of the hub which extends into a web portion of the hub, and the plunger is formed with opposed grooves co-operating with the web portion of the hub for guiding the plunger for movement in a direction radially of the hub.

6. A transmission and synchronizer according to claim 5, in which the synchronizer ring is formed with a lug extending into the radial slot of the hub, to achieve the said rotation of the synchronizer ring with the hub, and the detent member is arranged to abut an end surface of the lug to effect the axial movement of the synchronizer ring for torque-transmitting frictional interengagement of the frustoconical surfaces.

7. A transmission and synchronizer according to any one of claims 1 to 6, in which the sleeve clutch and the hub are formed with co-operating axially extending spline teeth by means of which the clutch is slidably mounted on the hub, the synchronizer ring is formed with a ring of external teeth provided with baulk chamfers for engagement by chamfered end portions of the spline teeth of the hub during synchronization of the rotary speeds of the drive element and of the shaft, and the rotary drive element is formed with a ring of external teeth for engagement by the spline teeth of the clutch to establish the positive-clutch drive connection between the rotary drive element and the shaft.

8. A transmission and synchronizer according to any one of claims 1 to 7, in which a second rotary drive element is disposed on the axial side of the hub remote from the first-mentioned rotary drive element, and a second synchronizer ring is disposed between the second drive element and the hub and is selectively engageable by the detent member for providing synchronization for positive-clutch engagement of the sleeve clutch with the second drive element.

9. A transmission and synchronizer according to claim 8, in which at least one of the rotary drive elements comprises a gear-wheel that is rotatably mounted on the rotary shaft and is in constant mesh with a respective driven countershaft gear.

10. A transmission and synchronizer substantially as hereinbefore particularly described and as shown in the accompanying drawing.