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E. B. WATSON

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AUTOMATIC ANGULARLY ADJUSTABLE COUPLING DEVICE

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FIG. 1

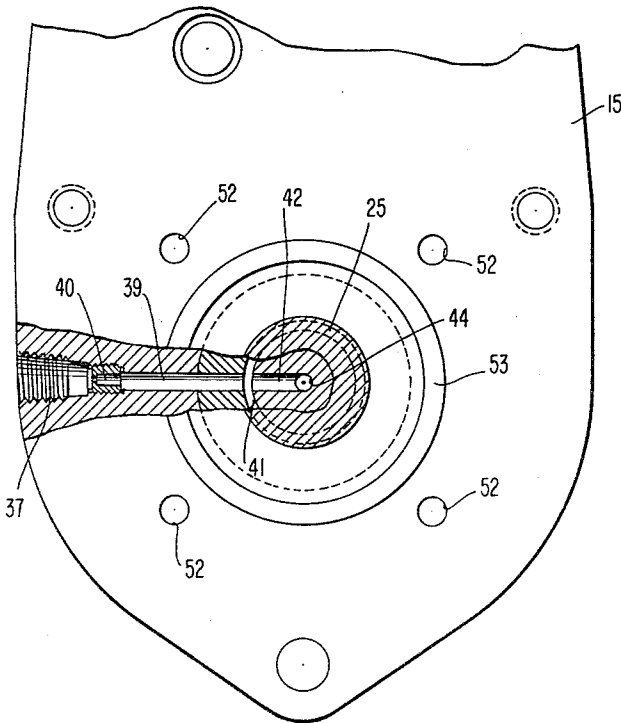
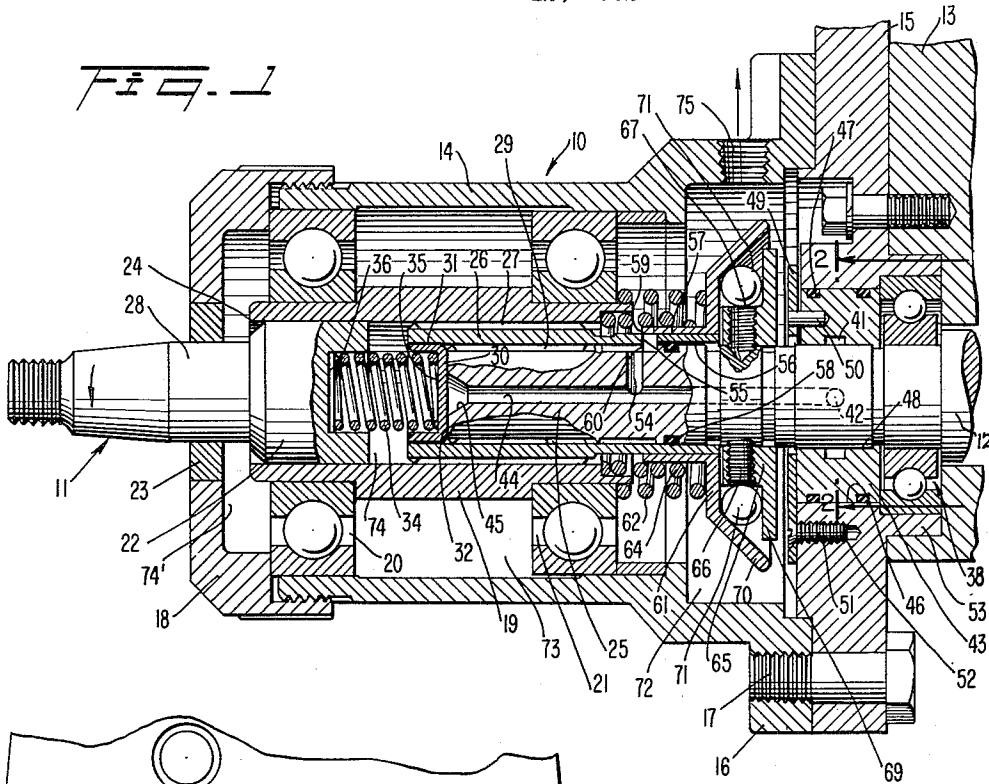


FIG. 2

INVENTOR

EDWIN B. WATSON

BY

Bauer and Seymour
ATTORNEYS

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AUTOMATIC ANGULARLY ADJUSTABLE COUPLING DEVICE

Edwin B. Watson, Sidney, N.Y., assignor to The Bendix Corporation, Sidney, N.Y., a corporation of Delaware
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This invention relates to apparatus for drivably connecting rotating parts while permitting and automatically controlling a limited relative angular movement between the parts in response to changes in rotational speed thereof.

The present invention has among its objects the provision of a novel automatic coupling device of the type indicated.

A further object of the invention lies in the provision of an automatic coupling device wherein the angular adjustment of one rotatable part with respect to the other is substantially unaffected by the driving torque to which the coupling device is subjected.

Another object of the invention lies in the provision of an automatic coupling device of novel construction incorporating a servo mechanism for changing the angularity between the rotating parts and a speed responsive mechanism for controlling the servo mechanism, whereby the coupling device is very sensitive to variations in the speed of rotation of the rotatable parts.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only, and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is a view in vertical axial section through an illustrative embodiment of automatically adjustable coupling device in accordance with the invention, certain of the parts being shown in elevation, the figure including a sectioned fragment of an injection type fuel pump driven by the adjustable coupling device of the invention; and

FIG. 2 is a fragmentary view in end elevation of the end mounting plate of the adjustable coupling device and of a central insert member or collar therein, a portion of such plate and collar being shown in vertical section, the section being taken along the line 2-2 of FIG. 1.

The illustrative embodiment of automatically adjustable coupling device is shown herein employed to drive a fuel pump of the injection type for use with an internal combustion engine. As the speed of such engine diminishes, the timing of the fuel injection to the cylinders thereof should, for optimum performance, be progressively retarded. As the engine speed increases, the fuel injection timing of the pump should be advanced. Consequently, it has been found necessary to provide speed responsive coupling means between the drive shaft of the fuel injection pump and the shaft of the engine from which it is driven. Prior adjustable coupling devices of this type, however, have been cumbersome, do not have the desired sensitivity to variations in speed of the engine, and are undesirably affected in their response by the varying torque imposed upon them caused by variations in engine speed, variations in fuel pump delivery, and to variations in fuel viscosity.

The automatic angularly adjustable coupling device of the present invention overcomes the above-outlined difficulties attendant upon prior such devices. It is simple in construction, compact in size, and has adequate power quickly to change the angular relationship of the driving and driven shafts to that required. The coupling of the

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invention includes a servo mechanism supplied, for example, with engine lubricating oil under pressure. Such servo mechanism is controlled by a sensitive speed responsive device which is unaffected by changes of torque between the driving and driven shafts of the coupling. Any momentary changes in the angular relationship between the driving and driven shafts of the coupling which is caused solely by variations in torque therebetween is quickly corrected by interaction between a movable shaft-coupling member and a valve member controlled by the speed responsive means. Consequently, the coupling device of the invention is stable in operation and does not tend to "hunt."

The illustrative timing device in accordance with the present invention is designated generally by the reference character 10. Timing device 10 has a stub drive shaft generally designated 11 projecting axially from the left hand end thereof, such shaft 11 being adapted to be connected to and driven in synchronism with the engine (not shown) with which device 10 is associated. Shaft 11 is drivingly connected to a shaft 12 having a portion extending axially from the right hand end of device 10. The fuel injection pump, of which the housing 13 is fragmentarily shown at the right in FIG. 1 of the engine, is adapted to be driven by shaft 12.

The timing device 10 adjustably couples shafts 11 and 12 together in synchronized relationship, device 10 being so constructed and arranged that, as the speed of the engine, and thus of the fuel injection pump, increases, the shaft 12 is angularly advanced relative to shaft 11 to the degree required to adjust the timing of injection of fuel by the fuel injection pump to produce the optimum timing of such fuel injection for the instantaneous engine speed.

Timing device 10 has a generally circular cylindrical hollow imperforate casing having a main body 14 which, in the embodiment shown, is mounted upon and closed by a plate 15 which is disposed transversely of the axis of casing 14. Plate 15 may be employed, for example, to attach the device 10 to the housing, fragmentarily shown at 13, of the fuel injection pump with which device 10 is employed. In the illustrative device, body 14 of the casing is provided at its right hand end with a radially outwardly directed flange 16 which is sealingly connected to the plate 15 by means of a plurality of machine screws 17 extending through openings in plate 15 and threadedly engaged in flange 16. The casing of device 10 is closed at its left hand end by a cap 18 which is threadedly connected to the body 14 of the casing. Shaft 11 extends through cap 18 and is sealed thereto by an annular seal 23 in the cap, such seal engaging a circular cylindrical portion 28 on shaft 11 so as to permit rotation of the shaft in the sealing means.

Rotatably mounted axially within the body 14 of the casing is an outer sleeve member 19. Sleeve 19 is supported in the main part of the casing by ball bearings 20 and 21 at its left and right hand ends, respectively, the inner races of such ball bearings being disposed in annular seats in sleeve 19 which hold the ball bearings a fixed axial distance from each other. Shaft 11 is drivingly connected to sleeve 19 by means of a head 22 on the inner end of the shaft, such head accurately fitting within the left hand end of sleeve 19 and being secured and sealed thereto by an annular weld 24.

The shaft 12 which drives the fuel injection pump has a portion 25 which extends axially inwardly of the casing and which is telescoped within the sleeve 19. Interposed between and coaxial of portion 25 of shaft 12 and sleeve 19 is an intermediate sleeve 26. The outer surface of sleeve 26 and the inner surface of sleeve 19 are provided with intermeshing straight splines indicated at 27 so that sleeve 26 is driven by shaft 11 and sleeve 19 at the same angular speed as that of such parts. Because of such

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straight spline engagement between sleeves 19 and 26, however, sleeve 26 may reciprocate axially of sleeve 19. The inner surface of sleeve 26 and the outer surface of the portion of shaft part 25 which confronts such sleeve are provided with intermeshing helical lands indicated at 29, so that axial reciprocation of sleeve 26 causes rotation of shaft 12 relative to sleeve 26 and thus relative to shaft 11. The direction of inclination or hand of the helical spline connection 29 is such that in its operative rotation, as in the direction of the arrow, shaft 11, acting through sleeve 19, urges the sleeve 26 into the right hand terminal position thereof shown in FIG. 1 when an opposing torque, such as is imposed by the driving of the fuel injection pump, is imposed upon the fuel pump shaft 12.

The inner or left hand end of sleeve 26 extends axially beyond the inner end surface 32 of shaft part 25. Such inner end of the sleeve 26 is sealed by a cup-shaped plug member 30 which is telescoped within the end of the sleeve and is welded and sealed thereto by an annular weld or brazed at an annular joint 31. Sleeve 26 and plug 30 form a closed-ended cylinder reciprocable axially of the device 10. The right hand end surface of the bottom of plug member 30 engages the end surface 32 of shaft part 25 to form a stop for the cylinder and thus for sleeve 26 when such sleeve is in the terminal position of FIG. 1. In the illustrative embodiment sleeve 26 is constantly urged toward such terminal position by a coil compression spring 34 having its right hand end positioned in a spring seat formed by the hollow interior of plug member 30 and its left hand end positioned in a spring seat 36 in the head 22 of shaft 11. It has been found, however, that in some instances the spring 34 is not necessary, since in operation its action mainly supplements the axial force upon the sleeve 26 developed at the helical spline connection. Spring 34 does have a desirable damping effect upon the movement of the sleeve.

As above explained, the device 10 is in the nature of a servo mechanism which is responsive to engine speed and which is powered by oil under pressure, such as the lubricating oil for the engine with which device 10 is employed. An oil inlet port 37, connected to the lubricating oil pressure source of the engine, is located in plate member 15, as shown in FIG. 2. Port 37 communicates with a passage 39 in plate 15, such passage extending radially of shaft 12. A removable orifice-providing insert 40 is preferably provided between port 37 and passage 39 in order suitably to reduce the pressure of the engine lubricating oil as it is fed to device 10. Passage 39 communicates with an annular groove 41 in the inner surface of a passage 48 in an annular insert or collar member 43 secured in a central bore 46 in plate 15. A radial passage 42 in shaft part 25 is aligned and communicates with annular groove 42. From the inner end of passage 42 there extends an axially disposed central passage 44 in shaft part 25, passage 44 extending to an outwardly flared opening 45 at the left hand end of the shaft. Thus during the running of the engine, oil under pressure is present in passages 39, 42, and 44, and the cylinder composed of the sleeve 26 and the plug 30 is subjected to an axial force which tends to displace it to the left by reason of the pressure which such oil exerts upon the closed end of such cylinder through the orifice 45.

The insert or collar 43 is retained in bore 46 in plate 15 in the following manner: A cover plate 49 through which the shaft part 25 extends is mounted upon the inner side of plate 15 and overlies collar 43. Plate 49 is retained upon plate 15 by a plurality of screws of which one is shown at 51, such screws being received within threaded passages 52 in plate 15. A dowel pin 50 driven into a passage in collar 43 has its outer end extending into a hole in plate 49 so as to prevent rotation of collar 43. Collar 43 is prevented from displacement

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to the right (FIG. 1) by a bearing 38 for shaft 12 in the fuel pump housing 13 which extends into a space provided within a fuel pump-locating flange 53 on plate 15 so as to overlie collar 43. Collar 43 is sealed to the wall of bore 46 in plate 15 by O-rings 47 disposed in annular grooves in member 43.

The right hand end portion of sleeve 26 is of somewhat reduced outer diameter, the outer surface of such portion 56 being of extended circular cylindrical shape. The inner surface of sleeve portion 56 is sealed to shaft part 25 by an O-ring 58 which is disposed in an annular groove in shaft part 25. Disposed radially within portion 56 of sleeve 26 is a radially outwardly directed passage 54 in shaft part 25, passage 54 extending outwardly from the central passage 44 to the outer surface of such shaft part. A single radially directed passage or port 55 is disposed in portion 56 of sleeve 26; in the embodiment shown passage 54 in port 55 is so located axially of each of such parts that when the sleeve 26 is in its right hand terminal position (FIG. 1), the left hand edge of port 55 is substantially aligned with the right hand edge of passage 54. Communication between passage 54 and port 55 is afforded at all times, however, by reason of the radial spacing between the outer surface of shaft part 25 at the outer end of passage 54 and the inner surface of sleeve part 56 at port 55. Such spacing is provided by the interengaging splines on shaft part 25 and sleeve 26 which form the helical spline connection 29.

Overlying and telescoped about the right hand end of portion 56 of sleeve 26 is a second, outer sleeve 57 which has sealing but axially slidable engagement with portion 56 of the sleeve 26. The sleeve 57 is of such axial length and is so positioned when it lies in the terminal position of FIG. 1 that its left hand edge 59 lies in substantial alignment with but slightly overlaps the left hand edge 60 of the port 55 in sleeve portion 56. Thus with the parts in the position of FIG. 1 the sleeve 57 functions to prevent escape of lubricating oil under pressure outwardly from port 55. The port 55 and the left hand end of sleeve 57 constitute an adjustable valve for bleeding oil under pressure at varying rates from the closed end of cylinder 26, 30.

Sleeve 57 is constantly urged to the right by a coil compression spring 62 which has the left hand end thereof engaged in the outer end of the seat which receives the outer race of ball bearing 21 and the right hand end thereof in engagement with a radially outwardly directed annular flange 61 connected to the right hand end of sleeve 57. In the embodiment shown there is employed a further, shorter spring 64 telescoped inwardly of spring 62, such spring 64 having its left hand end retained in a seat formed within the right hand end of sleeve 19. Spring 64 is of such axial length that its right hand end is not engaged by flange 61 during operation of the device 10 and the fuel pump at low speeds. The right hand end of spring 64 is engaged by flange 61 at higher speeds of the device 10. Thus at low speeds the position of sleeve 57 is a function of spring 62; at higher speeds the position of sleeve 57 is a function of the combined effects of springs 62 and 64.

The speed responsive device includes a spool 65 which is disposed about and secured to shaft part 25 by one or more set screws (two shown) 66 threaded into the spool and extending radially inwardly into seats in the shaft part 25. Spool 65 has a part-toroidal annular seat 67 thereon, the right hand end of such seat being bounded by the inner transversely disposed annular surface of an end flange 69 on the spool. The outer end of flange 61 on sleeve 57 is continued in a frusto conically directed portion 70 which flares to the right. Seat 67, the inner surface of flange 69, and the inner surface of flange 70 form an annular seat which receives a series of weights in the form of balls 71 therebetween. The balls are of such diameter and the confronting surfaces of flanges 61, 69, and 70 are so spaced by the balls, when the parts are

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in the position of FIG. 1, that the end edge 59 of sleeve 57 slightly overlaps the left hand edge 60 of port 55, thereby to close such port.

When port 55 is open, oil escapes from passage 44 through passage 54 and port 55 into the space within the casing 14 including space 72 at the right hand end thereof, space 73 intermediate the length of the casing, the space 74 between member 22 and cylinder 26, 30, and the space 74' within the cap 18. Oil from such connected spaces is exhausted from the casing through a port 75 which may be connected by a conduit (not shown) leading to the sump of the engine.

When the engine and thus the shafts and sleeves of device 10 are at rest, the parts of such device occupy the positions shown in FIG. 1. The left hand edge 60 of port 55 is then just slightly covered by the right hand edge 59 of sleeve 57, so that port 55 is closed. The balls 71 lie in their radially innermost position.

When the engine starts and idles, centrifugal force thrusts the balls 71 radially outwardly somewhat, to a position determined by engine speed, against the opposition of spring 62. This moves sleeve 57 to the left further past port 55. Engine lubricating oil under pressure enters passage 44, forcing the cylinder 26, 30 to the left against the opposition of the thrust to the right generated by the helical spline connection 29 and that of spring 34.

The forcing of the sleeve 26 to the left by the pressure of the engine lubricating oil acting upon the closed end of cylinder 26, 30 advances the shaft part 25 and thus shaft 12 angularly with respect to driving shaft 11, and thus advances the timing of fuel injection by the fuel injection pump. Movement of the sleeve 26 to the left, however, uncovers the port 55. This lowers the pressure of the lubricating oil acting upon cylinder 26, 30 to thrust the sleeve 26 to the left. As a result, sleeve 26 tends to move back somewhat to the right and thereby slightly to retard the timing of fuel injection by the fuel injection pump from its previously advanced condition. The sleeve 57, which functions in conjunction with port 55 as a valve member to determine the effective area of the bleeding valve 55, 59, is speed responsive, as we have seen. Thus upon an increase of the speed of the engine from its idling speed, the balls 71 are thrown further outwardly by centrifugal force and the sleeve 57 assumes a stable equilibrium position further to the left, thereby tending to close the valve 55, 59, to raise the pressure to which the cylinder 26, 30 is subjected, and thus to thrust sleeve 26 further to the left. Sleeve 26 then moves to the left sufficiently to open the valve 55, 59 to return the parts to stable condition. The reverse actions take place when engine speed decreases.

The position of the outer control sleeve 57 is determined purely as a function of speed of rotation of shaft 11. At a given position of the sleeve 57, the sleeve 26 will assume an axial position determined by a balance between the hydraulic force exerted on the cylinder 26, 30 tending to thrust sleeve 26 to the left and the torque reaction between the helical splines of connection 29 tending to thrust the sleeve 26 to the right, toward its terminal, engine-at-rest, position (FIG. 1). Any variation in the torque reaction between the shafts 11 and 12, that is, the torque upon shaft 12 to drive the fuel injecting pump, normally encountered during operation of the fuel pump, is compensated for as follows:

Upon a decrease in such torque reaction the sleeve 26 tends to move a slight distance to the left, thereby opening the valve orifice 55, 59 to drop the hydraulic pressure acting upon the cylinder 26, 30. Sleeve 26 then returns a slight distance to the right to a new equilibrium position only slightly removed from its former equilibrium position, thereby tending to close the valve orifice 55, 59 and slightly retarding the timing of the fuel injection pump.

Upon an increase in the torque reaction between the shafts 11 and 12, the interaction between the splines

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forming the helical connection 29 tends to move the sleeve 26 to the right, thereby closing the valve orifice 55, 59. This increases the hydraulic pressure acting upon the cylinder 26, 30, so that sleeve 26 is thrust to a new position to the left. This opens the valve orifice 55, 59 and also slightly advances the timing of the fuel injection pump. The changes in fuel pump injection timing caused by the described compensation for changes in pump driving torque normally encountered are insignificant.

It has been found that the interaction between the parts of the timing device 10 is such that the sleeve 26 tends to seek and stably remain at an axial position at which the force exerted thereon by the helical spline connection 29 which tends to thrust it to the right is balanced by the hydraulic pressure of the engine lubricating oil acting upon cylinder 26, 30 which tends to thrust sleeve 26 to the left. Such hydraulic pressure, as we have seen, is controlled by bleeder valve 55, 59, which is, in turn, under the control of the speed responsive mechanism 65, 71, 70, etc. The only variable in the system which has any substantial effect upon such equilibrium position of sleeve 26 is the speed of rotation of the shafts 11 and 12. So long as the inlet pressure of the lubricating oil is high enough completely to advance the timing of the fuel pump driven by shaft 12 at all speeds and at maximum driving torque required by such fuel injection pump, the operation of device 10 is not greatly influenced by variations in engine oil pressure by changes in speed of the engine. Any oil pressure which is in excess of such required minimum only tends to open port 55 slightly more. Thus the engine need not be provided with any special oil pressure regulating device. The position of sleeve 26 is also substantially unaffected by changes in the torque required to drive the fuel injection pump, since such changes in torque are automatically compensated for by the device 10 of the invention, as above explained. Changes in viscosity of the engine lubricating oil also have very little practical effect upon the operation of the device.

Although only one embodiment of the invention has been illustrated in the accompanying drawings and described in the foregoing specification, it is to be especially understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art. Thus the coupling device of the invention may be employed to drive any rotatable member such as a shaft from another shaft when a variation of the angular relationship through a limited range between the shafts in response to variations in the speed of rotation of the shafts is required.

What is claimed is:

1. A coupling mechanism for automatically effecting angular adjustment between two rotary coaxial shafts comprising a sleeve splined to both of said shafts with splines of different angularity, a fluid motor including said sleeve and an end portion of one of said shafts in telescopic relation with the sleeve to effect axial adjustment of the sleeve in one direction, means for continuously connecting said motor to a source of fluid pressure, and a regulating valve for controlling operation of said motor, said regulating valve comprising means providing a fluid conducting outlet port connected to said motor and movable with said sleeve and a valve member mounted for adjustment axially of the shafts for adjustably throttling said port, and means for moving said valve member.

2. Mechanism in accordance with claim 1, wherein the valve member is in the form of a second sleeve having telescopic relationship with the first recited sleeve at the location of the outlet port.

3. Mechanism in accordance with claim 2, wherein the first recited sleeve is telescoped over and supported by said one of the shafts.

4. A coupling mechanism for automatically effecting angular adjustment between two rotary coaxial shafts comprising a sleeve splined to both of said shafts with splines of different angularity, a fluid motor including said sleeve to effect axial adjustment of the sleeve, a regulating valve for controlling operation of said motor, said regulating valve comprising means providing a fluid conducting port connected to said motor and movable with said sleeve, and a valve member mounted for adjustment axially of the shafts for adjustably throttling said port, and means for moving the valve member comprising a speed sensitive mechanism connected to said valve member to move the valve member in a port-opening direction when the speed of the shafts decreases and in a port-closing direction when the speed of the shafts increases.

5. Mechanism in accordance with claim 4, wherein the speed sensitive mechanism comprises a plurality of weights mounted about the axis of the shafts, and weight-retaining means including an axially movable frusto-conical member mounted coaxial of the shafts and overlying the weights, said frusto-conical member being directly connected to said valve member.

6. A coupling mechanism for automatically effecting angular adjustment between two rotary coaxial members comprising an element splined to both of said members with splines of different angularity, a fluid motor including said element to effect axial adjustment of the latter, means for continuously connecting said motor to a source of fluid pressure for urging said element in one direction, valve means for controlling operation of said motor, said valve means comprising means providing a fluid outlet port connected to said motor and movable with said element and a valve member mounted for adjustment axially of said element for adjustably throttling said port, and means for moving said valve member.

7. Mechanism as defined in claim 6, wherein said element is a tubular sleeve surrounding an end portion of one of said rotary members.

8. Mechanism as defined in claim 7, wherein said sleeve is closed at one end and said end portion of said one rotary member constitutes a part of said fluid motor.

9. Mechanism as defined in claim 7 comprising resilient means interposed between said sleeve and the other of said rotary members for urging said sleeve in the opposite direction in opposition to said fluid motor.

10. Mechanism as defined in claim 6, wherein said valve member is a sleeve surrounding and slidable on said element.

11. Mechanism as defined in claim 10, wherein the means for moving the valve member comprises means responsive to the speed of rotation of said rotary members.

12. Mechanism as defined in claim 6 comprising resilient means for urging said element in the opposite direction in opposition to said fluid motor.

13. Mechanism as defined in claim 6, wherein the means for moving the valve member comprises resilient means for moving the valve member in one direction for opening said port and means responsive to the rotational speed of said rotary members for moving said valve member in the opposite direction for closing said port.

14. Mechanism comprising a first, driving shaft and a second, driven shaft disposed coaxially with respect to said first shaft, a sleeve coupling said shafts together and having differently angled spline connections with both to effect angular adjustment between said shafts upon axial adjustment of said sleeve, resilient means and a fluid motor including said sleeve to effect axial adjustment of the sleeve, means for continuously connecting said motor to a source of fluid pressure, a regulating valve for controlling operation of said motor, said regulating valve comprising means providing a fluid conducting outlet port connected to said motor and movable with said sleeve, and a valve member having telescopic relationship with and movable axially of the sleeve for adjustably throttling said port, and means for moving said valve member.

15. Mechanism as defined in claim 14, wherein said means for moving the valve member comprises centrifugally responsive means for moving the valve member in port closing direction and resilient means for moving the valve member in port opening direction.

16. Apparatus comprising a first, driving shaft, a second, driven shaft disposed coaxially with respect to said first shaft, a device connected to and driven by the second shaft, said device being of such character that the torque required to drive it increases significantly with an increase in its speed, a sleeve coupling said shafts together and having differently angled spline connections with both shafts to effect angular adjustment between said shafts upon axial adjustment of said sleeve, the spline connections being of such angularity that the sleeve is urged toward a first terminal axial position by the torque imposed therethrough upon the second shaft under operating conditions, a fluid motor including said sleeve variably to urge the sleeve axially in a reverse direction toward its other, second terminal position, means for continuously connecting said motor to a source of fluid pressure, a regulating valve for controlling operation of the fluid motor to vary the force with which the sleeve is thrust toward its second terminal position, said regulating valve comprising means providing a fluid conducting outlet port connected to said motor and movable with said sleeve, a valve member mounted for adjustment axially of the sleeve for adjustably throttling said port, and means for moving said valve member.

17. Apparatus comprising a first, driving shaft, a second, driven shaft disposed coaxially with respect to said first shaft, a device connected to and driven by the second shaft, said device being of such character that the torque required to drive it increases significantly with an increase in its speed, a sleeve coupling said shafts together and having differently angled spline connections with both shafts to effect angular adjustment between said shafts upon axial adjustment of said sleeve, the spline connections being of such angularity that the sleeve is urged toward a first terminal axial position by the torque imposed therethrough upon the second shaft under operating conditions, a fluid motor including said sleeve variably to urge the sleeve axially in a reverse direction toward its other, second terminal position, a regulating valve for controlling operation of the fluid motor to vary the force with which the sleeve is thrust toward its second terminal position, said regulating valve comprising means providing a fluid conducting port connected to said motor and movable with said sleeve, a valve member mounted for adjustment axially of the sleeve for adjustably throttling said port, and means responsive to variations in the speed of rotation of the shafts for moving said valve member, said last-named means being connected to move the valve member in a port opening direction when the speed of the shafts decreases and in a port closing direction when the speed of the shafts increases.

18. Apparatus comprising a first, driving shaft, a second, driven shaft disposed coaxially with respect to said first shaft, a fuel injection pump connected to and driven by the second shaft, said pump being of such character that the torque required to drive it increases significantly with an increase in its speed, a sleeve coupling said shafts together and having differently angled spline connections with both shafts to effect angular adjustment between said shafts upon axial adjustment of said sleeve, the spline connections being of such angularity that the sleeve is urged toward a first terminal axial position, wherein the timing of fuel injection by the pump is retarded, by the torque imposed therethrough upon the second shaft under operating conditions, a fluid motor operatively connected to said sleeve variably to urge the sleeve axially in a reverse direction toward its other, second terminal position wherein the timing of fuel injection by the pump is fully advanced, means for continuously connecting said motor to a source of fluid pressure, a regulating valve for con-

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trolling operation of the fluid motor to vary the force with which the sleeve is thrust toward its second terminal position, said regulating valve comprising means providing a fluid conducting outlet port connected to said motor and movable with said sleeve, a valve member mounted for adjustment axially of the sleeve for adjustably throttling said port, and means for moving said valve member.

19. Apparatus as defined in claim 18, wherein the means for moving said valve member is responsive to variations in the speed of rotation of the shafts so that said valve member is moved in port closing direction and the fluid motor thrusts the sleeve progressively further in said reverse, fuel injection advancing direction as the speed of rotation of the shafts increases.

20. A coupling mechanism comprising a rotatable first member having a hollow end portion, a rotatable second member coaxial with and telescopically received by said first member, a sleeve externally and internally splined to said first and second members, respectively, by splines of different angularity, whereby axial movement of the sleeve relative to said members will effect relative angular movement of said members, said sleeve being closed at one end and having a close sliding fit around said second member to form a fluid pressure motor, means for continuously connecting said fluid motor to a source of fluid pressure for urging said sleeve axially in one direction, the splined connections between said sleeve and said first and second members being such that when the first member is driving the second member the torque applied through said sleeve tends to move the latter axially in the other direction in opposition to the fluid motor, valve means rotatable with said sleeve for controlling the flow of fluid from said

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motor comprising port means in said sleeve and an axially adjustable valve member for adjustably throttling said port means, resilient means interposed between said first member and said valve member for yieldably urging the latter axially in a direction to open said port means, and means responsive to the rotational speed of said second member for urging said valve member axially in a direction to close said port means as the speed of rotation of said second member increases.

21. Mechanism as defined in claim 20 comprising resilient means interposed between said sleeve and said first member for yieldably urging said sleeve axially in said other direction in opposition to the fluid motor.

22. Mechanism as defined in claim 20, wherein said means for connecting the fluid motor to a source of fluid pressure includes an axially extending passage in the end portion of said second member surrounded by said sleeve.

23. Mechanism as defined in claim 20, wherein said means for connecting the fluid motor to a source of fluid pressure includes a restrictive orifice between said motor and the source.

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