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(56) Documents Cited:
GB 2338277 A **EP 0786368 A**
JP 600196436 A **US 4804074 A**
US 4084670 A

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UK CL (Edition V) **F2L**
INT CL[7] **B60K, F16D**
Other: **Online: WPI, EPODOC, JAPIO.**

(54) Abstract Title: **Clutch control system for automatically controlling a friction clutch in a motor vehicle**

(57) A friction clutch controller for a motor vehicle to improve hill starts, includes an engine speed sensor 24, a vehicle speed sensor 57, gear sensor 32 and a brake release sensor 66,68,72. The control causing partial engagement of the clutch 14 after a reduction in degree of actuation of the brakes, when the vehicle is at rest with the brakes applied, with a gear selected and the engine revolution rate lies below a defined value. The clutch 14 is disengaged after a period of 0.5-4 seconds from cessation of braking if the accelerator is not pressed.

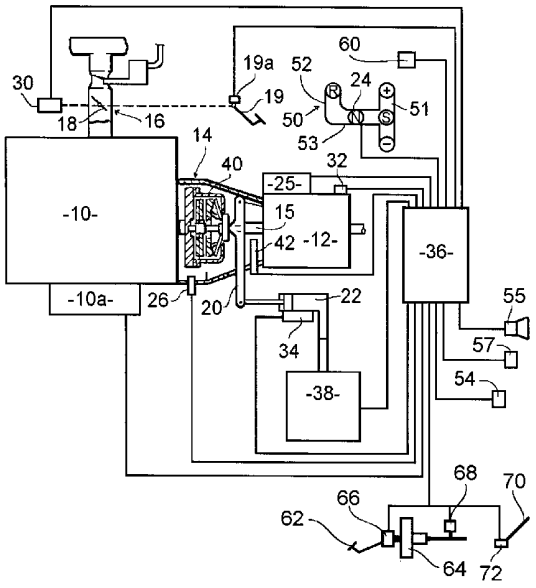

Fig 1.

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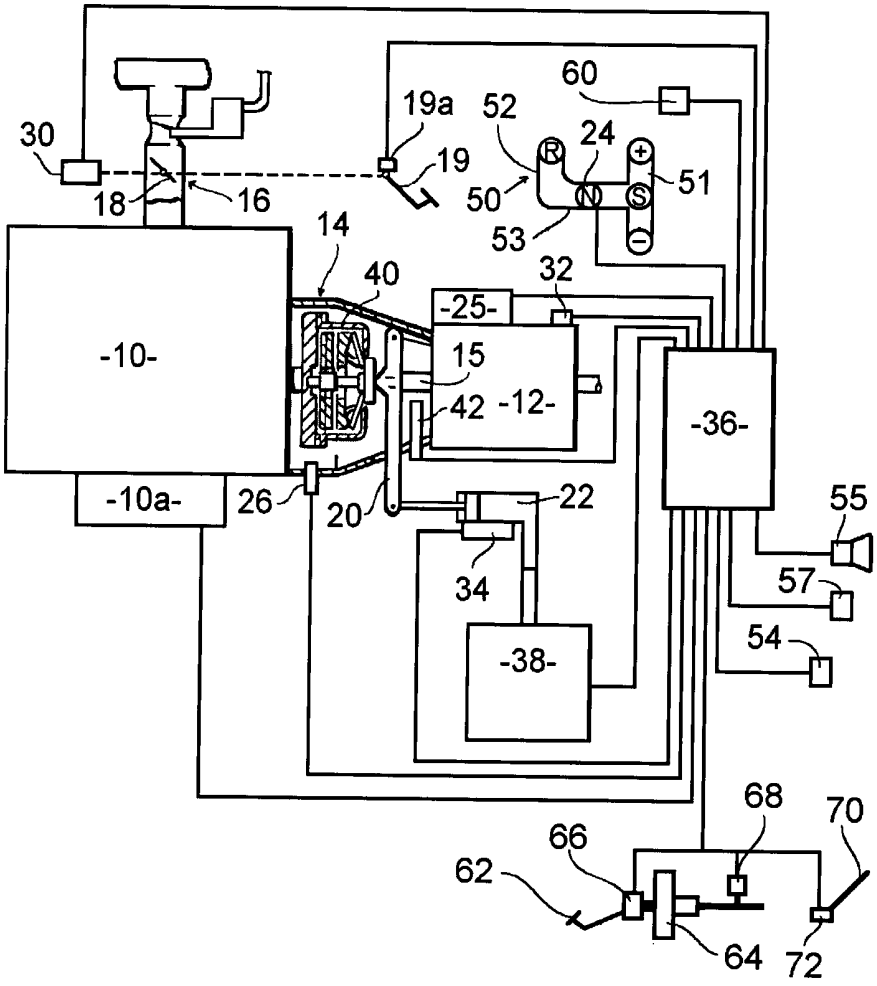
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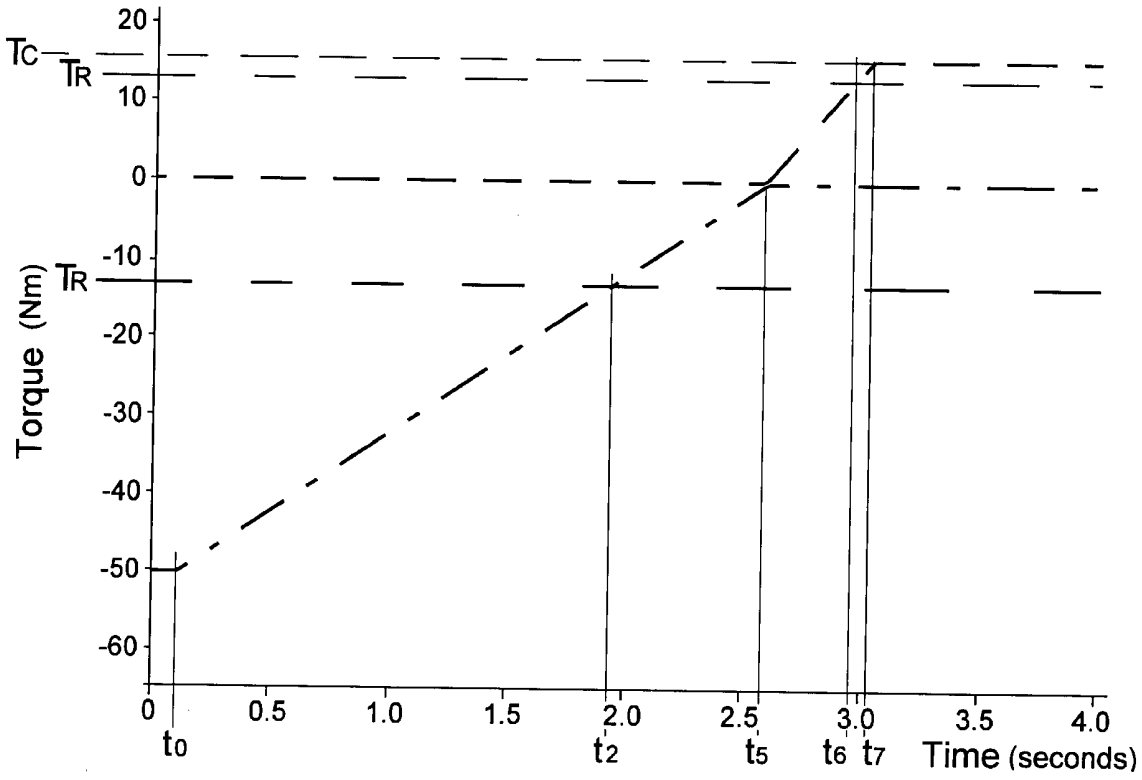
66
62
64
72

Fig 1.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1.5
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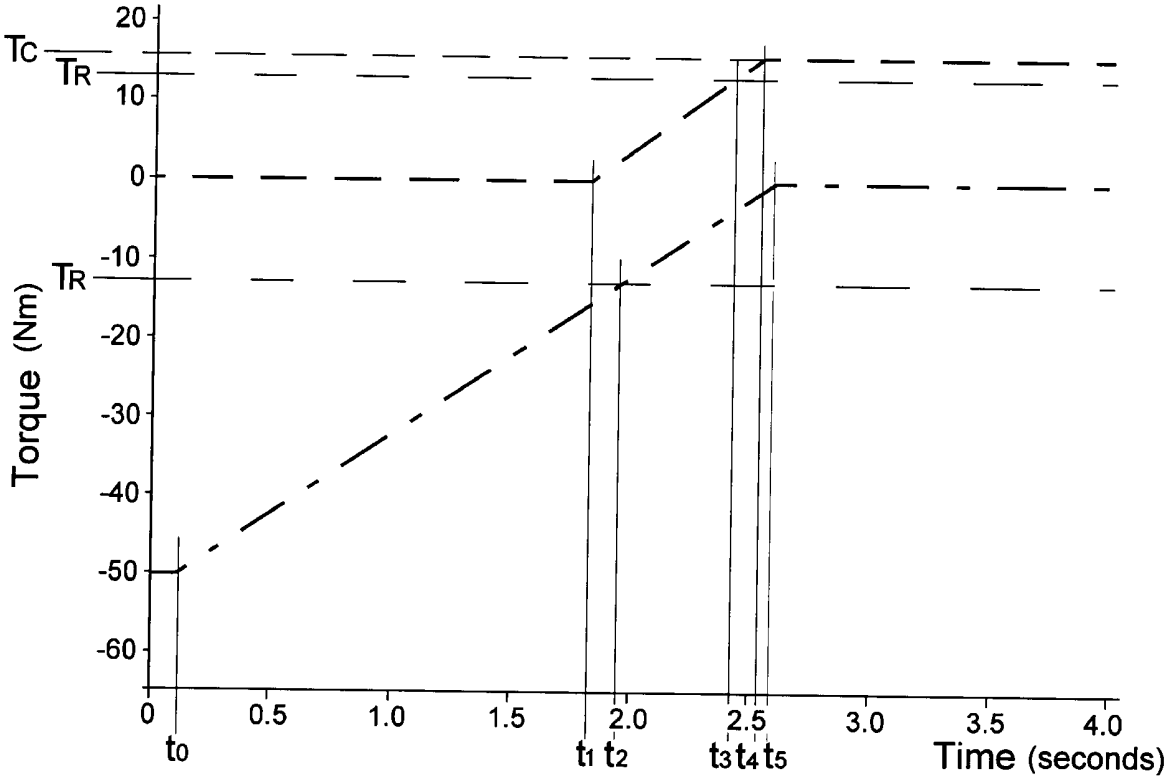
3.0
3.5
4.0
t0
t2
t5
t6
t7
Time (seconds)

Fig 2a.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1.5
2.0
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3.0
3.5
4.0
t0
t1
t2
t3
t4
t5
Time (seconds)

Fig 2b.

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CLUTCH CONTROL SYSTEMS

The present invention relates to clutch control systems and in particular clutch control systems for automatically controlling engagement and disengagement of a friction clutch located in the drive line between a vehicle engine and a gearbox.

With conventional manual transmission systems, the starting of a vehicle presents a co-ordination problem to the driver, requiring the progressive release of the parking brake at the same time as the engine speed is increased and the clutch is engaged to deliver an increasing drive torque to the transmission. Starting a vehicle of this type on a gradient and preventing the vehicle from rolling down the gradient, commands considerable skill from the driver and for the driver to be familiar with the characteristics of the engine, clutch and parking brake of the vehicle and to take account of the gradient and vehicle loading.

For vehicles with automatic transmissions which use a torque converter interposed between the engine and the automatic gearbox, there is no clutch pedal so the demands on the driver when starting the vehicle on a gradient are less severe. The characteristics of the torque converter are such that at engine idling speed with the vehicle at rest, a small torque is transmitted from the engine to the gearbox when a gear ratio suitable for starting from rest is engaged. This torque, which is amplified by the transmission and delivered to the driving wheels, is sufficient to overcome the static rolling friction of the vehicle. The consequence of this is that when the parking brake is released, the vehicle will be set in motion in the direction determined by the transmission control lever, if the vehicle is on the flat or a slight gradient. This behaviour is referred to as "creep". To set the vehicle in motion on a more severe gradient

without rolling back it is sufficient for the driver to accelerate the engine and release the parking brake. Provided that the engine has been accelerated to deliver sufficient torque to overcome the static friction and the gravitational forces, before the brake is released, the vehicle will move off without rolling back. The provision of creep makes the control of starting from rest on the flat or a slight gradient relatively simple for the driver. The vehicle is set in motion by setting the transmission control lever and releasing the brake pedal. The subsequent acceleration is controlled by the throttle pedal.

With transmission systems of the type covered by the present application, for example as disclosed in European Patent Nos. 0038113; 0043660; 0059035 and 0101220, the disclosure content of which are incorporated into the disclosure content of the present invention by reference thereto, the clutch control system may, for example, include an electronic control unit which controls the initial clutch take-up on starting the vehicle, clutch re-engagement following each ratio change, clutch disengagement to change the operative ratio of the gearbox and clutch disengagement on coming to rest of the vehicle, the level of clutch engagement during take-up or starting of the vehicle being controlled in response to an engine speed error signal derived from a comparison of current engine speed and a reference speed signal generated by the control unit. Transmission systems of this type do not usually provide a creep facility. Whilst a torque converter is able to deliver a small torque to the vehicle transmission indefinitely while the vehicle remains at rest, an automated friction clutch as used in transmission systems of the type to which the present application applies, is unable to operate similarly without accumulating unacceptable wear.

With vehicles having transmission systems of this type, starting from rest on a gradient, using the brake pedal and optionally the parking brake, the braking

action ceases once the driver's foot has been transferred from the brake pedal to the accelerator pedal and the parking brake has been released. There will be a delay whilst the driver's foot is transferred from the brake pedal to accelerator pedal and a further delay after the accelerator pedal is pressed before the engine speed increases and in response to this increasing speed the clutch engages to deliver the torque to the transmission to set the vehicle in motion.

During this delay period there will be a tendency for the vehicle to roll down the gradient, unless the driver controls the vehicle motion with the parking brake. There is a reluctance by drivers to use the parking brake under these circumstances because its use involves considerable skill and there is a tendency for the driver to allow the vehicle to roll down the gradient or to race the engine. It would consequently be advantageous in transmission systems of this type, to deliver a level of torque equivalent to the creep torque normally delivered by a torque converter of an automatic transmission system, when braking torque ceases to be available. Once the clutch has been moved to a position where a small torque is transmitted, only a small further movement of the clutch is required to increase the torque to a level where the vehicle can be set in motion on a gradient.

In accordance with GB 2338277, the disclosure content of which is incorporated into the disclosure content of the present invention by reference thereto, upon selection of a gear ratio and release of the brake, the clutch will partially engage and deliver a torque to the driving wheels of the vehicle, which is sufficient to overcome the static rolling friction of the vehicle. This will tend to hold the vehicle on the gradient until the engine is accelerated to increase the engine speed and clutch engagement to a degree where sufficient torque is delivered to the driving wheels of the vehicle, so that the vehicle will move away. With such an arrangement, the ability of the driver to set the vehicle in motion on a

gradient is greatly improved by virtue of the creep facility which anticipates the initial action of the take-up control in raising the clutch torque up to the level of the creep torque.

However in accordance with GB2338277, the creep torque is decreased to zero, when the brakes are re-applied and the creep torque will be applied only when the brakes are fully released. As there is a delay between release of the brakes and the establishment of sufficient creep torque, the vehicle will roll back, even on a small incline.

According to one aspect of the present invention, a clutch control system for a motor vehicle having an engine, a gearbox, having a plurality of drive ratios and a gear selection means, the engine being drivingly connected to the gearbox by a friction clutch; the clutch control system automatically controlling engagement and disengagement of the clutch in synchronisation with actuation of the gear selection means, to alter the gearbox drive ratios, the clutch control system including an engine speed sensor which generates an engine speed signal variable with the engine speed, a vehicle speed sensor, a gear ratio selection sensor, a brake release sensor to sense the degree of actuation of a brake of the vehicle and clutch actuation means to partially engage the clutch as the degree of actuation of the brake decreases when, prior to a reduction in the degree of actuation of the brake, the sensors indicate that the vehicle is substantially at rest, the brake is applied, a gear ratio is selected and the engine speed is below a predetermined value.

With the clutch control system of the present invention the degree of engagement of the clutch may be increased as the degree of actuation of the brake decreases, so that when the torque applied by the brake falls below that

necessary to hold a vehicle on an incline, the creep torque applied by the clutch will be sufficient to hold the vehicle.

To protect the clutch from excessive wear, the clutch control system preferably returns the clutch to a position where no torque is transmitted, if the level of torque determined by the take-up control has not exceeded the creep torque within a specified time, for example four seconds after the braking action ceases. Alternatively or in addition, the creep torque applied by the clutch may be decreased if the gradient of the change in the degree of brake actuation, during release of the brake falls below a predetermined value.

The brake release sensors of the present invention may furthermore be used to control disengagement of the clutch, as the vehicle is coming to rest. Hitherto disengagement of the clutch in these circumstances has been controlled as a function of vehicle deceleration, calculated on the basis of vehicle speed utilising, for example wheel speed sensors. However, the need to calculate deceleration from the vehicle speed will involve delays and moreover below a certain speed the signal from the wheel speed sensors becomes unreliable and can not be used for this purpose. The brake sensors of the present invention will provide a more direct indication of vehicle deceleration, thereby minimising delays.

An embodiment of the invention is now described, by way of example only, with reference to the accompanying drawings in which

Figure 1 is a diagrammatic illustration, the general layout of clutch control system in accordance with the present invention;

Figure 2a shows plots of brake torque and clutch torque against time for a clutch control system as disclosed in GB 2338277; and

Figure 2b shows plots of brake torque and clutch torque against time for a clutch control system in accordance with the present invention.

Figure 1 of the accompanying drawings shows an engine 10 with a starter and associated starter circuit 10a which is coupled through the main drive friction clutch 14 to a multi-speed synchromeshed lay shaft-type gearbox 12, via a gearbox input shaft 15. Fuel is supplied to the engine by a throttle 16 which includes a throttle valve 18, operated by accelerator pedal 19. The invention is equally applicable to electronic or mechanical fuel injection petrol or diesel engine.

The clutch 14 is actuated by a release fork 20 which is operated by a hydraulic slave cylinder 22, under the control of a clutch actuator control means 38.

A gear selector lever 24 operates in a gate 50 having two limbs 51 and 52 joined by a cross track 53 extending between the end of limb 52 and intermediate of the ends of limb 51. The gate 50 defines five positions; "R" at the end of limb 52; "N" intermediate of the ends of the cross track 53; "S" at the junction of limb 51 with the cross track 53; and "+" and "-" at the extremities of limb 51. In limb 51 the lever 24 is biased to the central "S" position. The "N" position of the selector lever 24 corresponds to neutral; "R" corresponds to selection of reverse gear; "S" corresponds to selection of a forward drive mode; momentary movement of the lever to the "+" position provides a command to cause the gearbox to shift up one gear ratio; and momentary movement of the gear lever 24 to the "-" position provides a command to cause the gearbox to shift down one gear ratio.

The positions of the lever 24 are sensed by a series of sensors, for example micro switches or optical sensors, positioned around the gate 50. Signals from the sensors are fed to an electronic control unit 36. An output from the control unit 36 controls a gear engaging mechanism 25, which engages the gear ratios of the gearbox 12, in accordance with movement of the selector lever 24 by the vehicle operator. The gear engaging mechanism 25 may, for example, comprise hydraulic rams and solenoid control valves to move selector members to engage and disengage the various gear ratios, for example as disclosed in patent specification WO97/05410 the disclosure of which is incorporated herein by reference thereto.

In addition to signals from the gear selector lever 24, the control unit 36 receives signals from:

sensor 19a indicative of the degree of depression of the accelerator pedal 19;

sensor 30 indicative of the degree of opening of the throttle control valve 18;

sensor 26 indicative of the engine speed;

sensor 42 indicative of the speed of the clutch driven plate;

sensor 34 indicative of the clutch slave cylinder position; and

sensor 32 indicative of the gear ratio selected.

The control unit 36 utilises the signals from these sensors to control actuation of the clutch 14 during take-up from rest and gear changes, for example as described in patent specifications EP0038113, EP0043660, EP0059035, EP0101220 and WO92/13208 to the disclosure of which explicit reference is made and whose content is expressly incorporated in the disclosure content of the present application.

A buzzer 55 is connected to the control unit 36 to warn/indicate to the vehicle operator as certain operating conditions occur. In addition or in place of the buzzer 55 a flashing warning light or other indicating means may be used. A gear indicator 60 is also provided to indicate the gear ratio selected.

A main braking system of the vehicle, includes a brake pedal 62 which operates a master cylinder 64 the apply hydraulic pressure to a brake system in order to brake the vehicle. A sensor 66 associated with the brake pedal 64, senses movement of the pedal 64 and sends a signal to the control unit 36, indicative of the degree of actuation of the main brake and/or a pressure sensor 68 measures hydraulic pressure in the brake system and sends a signal to the to the control unit 36, indicative of the pressure in the brake system. Alternatively or in addition, a sensor 72 senses movement of a parking brake lever 70 and sends a signal to control unit 36, indicative of degree of actuation of the parking brake.

In addition to the above mentioned sensors, control unit 36 also receives signals from a wheel speed sensor 57, ignition switch 54.

With the transmission system described above, when starting the vehicle from rest, actuation of the gear ratio selector lever 18 to engage a gear, will cause the clutch control unit 21 via the hydraulic control 22, to disengage the clutch 14. On subsequent release of the brake pedal 62 and/or parking brake lever 70, before the brake torque falls below a torque required to overcome the rolling resistance of the vehicle and any gradient resistance, the control unit 36 will cause the clutch control unit 21 via the hydraulic control 22 to partially engage the clutch 14 to apply a pre-set creep torque to the wheels of the vehicle, the pre-set creep torque being in excess of the torque Tc required to overcome the rolling resistance of the vehicle. The clutch torque is preferably increased at a rate equal to or greater that the rate at which brake torque is

released, so that the net torque applied by the brake and the clutch is equal to or greater that the per-set creep torque. As the engine speed is subsequently increased, the degree to which the clutch is engaged will increase under the normal take-up control of the clutch control system, until it exceeds the partial pre-engagement of the clutch 14, so that the torque applied to the wheels is then increased until the vehicle moves away.

Figure 2a represents a start-up utilising the clutch control system disclosed in GB2338277. As illustrated in figure 2a, the brakes begin to be released at time t_0. However, the clutch 14 does not begin to be partially applied until the brake torque is reduced to zero, at time t_5. Moreover the torque applied by the clutch 14 does not reach the pre-set creep torque level T_C until time t_7. As a consequence the net torque applied by the brakes and clutch between times t_2 and t_6, will be below the torque T_R, the torque required to prevent the vehicle from rolling backwards when parked on an incline.

In accordance with the present invention, as illustrated in figure 2b, partial engagement of the clutch 14 commences at time t_1, that is before the brake torque falls below the torque T_R, the torque required to prevent the vehicle from rolling backwards when parked on an incline, at time t_2. Moreover, the clutch torque is increased at a similar rate to the decrease in brake torque. In this manner, between times t_2 and t_3, the net torque applied by the brake and clutch 14 is maintained above the torque T_R required to prevent the vehicle from rolling backwards. Clutch engagement continues to be increased until at time t_4 the torque applied by the clutch reaches the pre-set creep torque T_C, which is in excess of the torque required to overcome the rolling and gradient resistance of the vehicle, so that the vehicle will begin to start-up from rest. Acceleration of the vehicle away from rest will however depend on actuation of the accelerator pedal 19 by the driver, in conventional manner.

To prevent unacceptable clutch wear, partial engagement of the clutch 11 after the cessation of the braking force, is terminated if the level of torque determined by the normal take-up control of the clutch control system does not exceed the creep torque within a time-out period, typically between half a second and four seconds. Thus, if no attempt is made by the driver to set the vehicle in motion within an allotted time after the braking effort ceases, the assistance provided by the application of creep torque, is terminated.

When the clutch 14 is partially pre-engaged during start-up from rest, the drag of the clutch will cause a reduction in the engine speed. If this reduction is excessive, then the engine is likely to stall. The probability of such an occurrence will depend on the degree to which the clutch is pre-engaged and the delay in depression of the accelerator pedal after the cessation of the braking. In order to avoid this problem the clutch control system may furthermore be arranged to immediately disengage the clutch 14 after cessation of the braking action if the accelerator pedal is not depressed and the engine speed drops below a threshold speed. Preferably said threshold speed will be below the idle speed of the engine when the clutch 14 is fully disengaged.

The torque applied by the clutch 14 may also be decreased, if the gradient of the change in brake torque, during release of the brakes, falls below a predetermined value.

Various modifications may be made without departing from the invention. For example, while the above description refers to the clutch control system disclosed in the European Patent Specification 0038113, this invention applies to any transmission system in which drive between an engine and gearbox is controlled by an automatically actuated friction clutch. Also, while in the above

embodiment, the clutch is controlled by hydraulic means, any other suitable means may be used. For example the slave cylinder 17 may be driven pneumatically rather than hydraulically. Alternatively an electrical actuator, for example an electronic motor, which may drive the release fork 16 by a suitable gear system, if required, may be used.

The patent claims submitted with the application are proposed formulations without prejudice to the achievement of further patent protection. The applicant reserves the right to submit claims for further combinations of characteristics, previously only disclosed in the description and/or drawings.

References back used in sub-claims refer to the further development of the subject of the main claim by the characteristics of the respective sub-claim; they are not to be understood as a waiver with regard to achieving independent item protection for the combination of characteristics in the related sub-claims.

Since the subject of the sub-claims can form separate and independent inventions with reference to the prior art on the priority date, the applicant reserves the right to make them the subject of independent claims or of division declarations. Furthermore, they may also contain independent inventions, which demonstrate a design, which is independent of one of the objects of the preceding sub-claims.

The embodiments are not to be considered a restriction of the invention. Rather, a wide range of amendments and modifications is possible within the scope of the current disclosure, especially those variations, elements and combinations and/or materials which, for example, the expert can learn by combining individual ones together with those in the general description and embodiments in addition to characteristics and/or elements or process stages

described in the claims and contained in the drawings with the aim of solving a task thus leading to a new object or new process stages or sequences of process stages via combinable characteristics, even where they concern manufacturing, testing and work processes.

Claims

1. A clutch control system for a motor vehicle having an engine, a gearbox, having a plurality of drive ratios and a gear selection means, the engine being drivingly connected to the gearbox by a friction clutch; the clutch control system automatically controlling engagement and disengagement of the clutch in synchronisation with actuation of the gear selection means, to alter the gearbox drive ratios, the clutch control system including an engine speed sensor which generates an engine speed signal variable with the engine speed, a vehicle speed sensor, a gear ratio selection sensor, a brake release sensor to sense the degree of actuation of a brake of the vehicle and clutch actuation means to partially engage the clutch as the degree of actuation of the brake decreases when, prior to a reduction in the degree of actuation of the brake, the sensors indicate that the vehicle is substantially at rest, the brake is applied, a gear ratio is selected and the engine speed is below a predetermined value.

2. A clutch control system according to claim 1, in which the brake release sensor acts on a brake pedal and/or parking brake lever.

3. A clutch control system according to claim 1 or 2, in which the brake release sensor senses the degree of movement of the brake pedal and/or parking brake lever.

4. A clutch control system according to claim 1 or 2, in which the brake release sensor senses the pressure a brake control system.

5. A clutch control system according to any one of claims 1 or 4 in which the engagement of the clutch provides a torque sufficient to overcome the rolling friction of the vehicle.

6. A clutch control system according to claim 5 in which the control system takes account of the operative gear ratio to determine the level of clutch engagement required to be transmitted by one or more driving wheels to overcome the rolling friction of the vehicle.

7. A clutch control system according to any one of the preceding claims in which full engagement of the clutch is controlled in accordance with the engine speed, the partial engagement of the clutch after cessation of the braking force being terminated, if the level of torque determined by normal take-up control of the clutch control system does not exceed the torque achieved by partial pre-engagement, within a predetermined time-out period.

8. A clutch control system according to claim 7 in which the timing period is between half a second and four seconds from the cessation of the braking force.

9. A clutch control system according to any one of the preceding claims including a throttle sensor, the control system being arranged to immediately to disengage the clutch after cessation of the braking action, if the throttle sensor indicates that the throttle is not actuated and the engine speed drops below a threshold speed.

10. A clutch control system according to claim 9 in which the threshold speed is below the idle speed of the engine when the clutch is fully disengaged.

11. A clutch control system according to any one of the preceding claims in which engagement and disengagement of the clutch is controlled by means of a hydraulic, pneumatic or electrical actuator.

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12. A clutch control system substantially as described herein with reference to and as shown in figures 1 and 2b of the accompanying drawings.

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Application No: GB 0221355.1 **Examiner:** Joe Mitchell
Claims searched: 1-12 **Date of search:** 19 March 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
Y	2-12	GB 2338277 A	LUK LEAMINGTON LIMITED (dependent claims disclose the dependent claims 2-12 of the current application)
X,Y	X:1,Y2-12	EP 0786368 A	TOYOTA MOTOR CO LTD (see statements of invention)
X,Y	X:1,Y2-12	US 4804074 A	AISIN SEIKI (see statements of invention)
X,Y	X:1,Y2-12	US 4084670 A	TOYO UMPANKI CO LTD (see statements of invention)
X,Y	X:1,Y2-12	JP 60196436 A	TOYOTA MOTOR CO LTD (see PAJ abstract)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

F2L

Worldwide search of patent documents classified in the following areas of the IPC[7]:

B60K ; F16D

The following online and other databases have been used in the preparation of this search report:

Online: WPI, EPODOC, JAPIO.