

Development of New Honda Techmatic System

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ABSTRACT

A new manually operated “Honda Techmatic System” auxiliary driving device that supports the independence of people with lower limb disabilities was developed and installed in a Honda FIT.

This development aimed to secure safety and reliability as official Honda product features, greatly advance operability from simply providing “the ability to drive” to “enjoying driving (Fun for Everyone),” secure compatibility with various car models, and enable easy installation.

This paper describes the specific structure used to achieve these goals, and the control lever design that blends with the cabin interior. It also introduces the history of driver’s licenses for disabled persons, and this market.

1. Introduction

The normal operation system layout for automobiles enables smooth driving by performing accelerator and brake operations with the feet and steering and various switch operations with the hands. This makes driving an automobile a challenge for persons with disabilities, congenital or otherwise, who mainly use self-propelled wheelchairs in their daily lives. The term “barrier-free” has been used for some time, but there are still many obstacles hindering the efficient movement of wheelchair users by means of public transportation. This makes cars an even more indispensable tool for wheelchair users than for fully able persons, and manually operated auxiliary driving devices enable accelerator and brake operations to be performed by hand to support the social independence of wheelchair users.

Most manually operated auxiliary driving devices are retrofitted after the license plates are acquired, and do not require any particular application for conversion. However, as these are important devices that control running and stopping, reliability equivalent to that of the accelerator and brake pedals of the base vehicle is required. The goals when developing the new Techmatic System were to secure safety and reliability as official Honda product features, to greatly advance operability

from just “the ability to drive” to “enjoying driving (Fun for Everyone),” to make the system compatible with various car models, and to make installation easy.

2. History and Types of Manually Operated Auxiliary Driving Devices

The first driver’s license in Japan was issued in 1907. Some 53 years later, the Road Traffic Act revision of December 1960 changed the conditions for obtaining a driver’s license, enabling disabled persons to also operate automobiles with the assistance of devices (Fig. 1)⁽¹⁾. As of 2008, there are approximately 77.96 million people with regular automobile driver’s licenses in Japan, and of these approximately 210000, or roughly 0.27%, hold conditional driver’s licenses limited to “vehicles for the physically disabled.”⁽²⁾

The market scale is approximately 5000 vehicles per year, of which two specialty manufacturers account for approximately 90%, while the three automobile manufacturers, Honda, Toyota, and Nissan, have also entered the market.

Honda’s efforts in this area began in 1968 with installation of manually operated auxiliary driving devices by the former Techland Co., Ltd. under the trademark “Techmatic System.” This was then carried over to the

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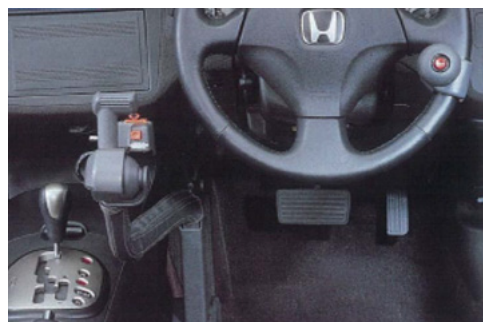
former Honda Tokuso Co., Ltd., and currently continues with Honda Logistics Inc.

Manually operated auxiliary driving devices have approximately a half-century of history since their commercialization. Recently, drive-by-wire types that use special actuators have been developed in Europe and the U.S., but most are still mechanical types that do not rely on electronic devices, and the basic structures have not changed much.

Mechanical-type manually operated auxiliary driving devices should operate the brake and accelerator pedals, which are normally operated by the feet, without multiplying the operating force. Therefore, the conventional structure uses relatively long control levers to operate the pedals using link mechanisms added to the



Fig. 1 Manually operated auxiliary driving device



(a) Floor type



(b) Column type

Fig. 2 Types of auxiliary driving device operated by hand

pedals, via rods or cables.

As shown in Fig. 2, there are two types of control lever mounting systems: the floor system that mounts the rotating axis mechanism on the vehicle center side of the driver's seat floor; and the column system that mounts the rotating axis mechanism below the steering column.

In addition, there are also two types of accelerator and brake operation systems. The first type is the single axis system that uses an integrated control lever, and operates the accelerator by pulling the lever toward the rear, and the brake by pushing the lever toward the front of the vehicle. The second type is the dual axis system that has an additional rotation axis on the upper part of the control lever. This system operates the accelerator by rotating only the upper part of the lever toward the rear around the upper axis, and the brake by rotating the entire lever toward the front around the rotation axis at the base of the lever.

3. Structure of the New Techmatic Model

In creating the new model Techmatic System, the basic structure of the control lever was addressed first out of consideration for operability that enables "enjoying driving." This led to adoption of a single-axis short-lever system that combines a shorter control lever, which reduces the distance the elbow moves, with a single-axis system, which is a clearly defined operation system.

In a single-axis short-lever system, the lever is located at a level higher than the driver's seat to reduce interference with the seat cushion, even when the seat is slid forward or backward. This also better secures the necessary control lever stroke for use with instrument panels of different shapes, and is advantageous in terms of mountability on the vehicle.

Safety reliability was further satisfied by installing a double brake cable, a drum with built-in equalizer mechanism, and a forced drum rotation mechanism. An operation gain variable mechanism and a built-in switch were adopted for greater driving enjoyment. Additional measures taken for mountability were adoption of a floor-mounted mechanism and of a cable mechanism as the means for transmitting the operating force. Figure 3 shows the overall structure. It is composed of the control lever assembly (C. L. A.) in the input section and the pedal link assembly (P. L. A.) that moves the vehicle brake pedal and accelerator pedal. This explanation will center on these two parts.

3.1. Control Lever Assembly

3.1.1. Design and functions

The control grip is an important interface that the driver touches directly with their hands to perform accelerator and brake operations, so not only is good operability demanded, but this lever is located in a highly visible position for the user, which also necessitates a

good design. The conventional control grip was considered to have good operability, but it could be said that the design was somewhat lacking in many cases. This development also gave sufficient consideration to design aspects, and realized a control grip that does not clash with the interior of the vehicle.

Grip shapes include the “I-type,” that is grasped from the side and the “T type” that is grasped from on top. The newly developed device was based on the T-type to enable a wider range of users. Design verification and practical verification were repeated using a mock-up model shown in Fig. 4. The optimal switch layout, grip sizes, and section shapes were verified, and the design was fine-tuned down to the smallest detail, including the angle R of parts touched by the user’s hand. An aluminum die-cast grip frame was used to secure sufficient strength and rigidity, and the surface was covered with real leather to give a high-class appearance for enhanced product appeal, and also to effectively reduce slipping due to perspiration.

Aluminum die-cast was also used for the housing that

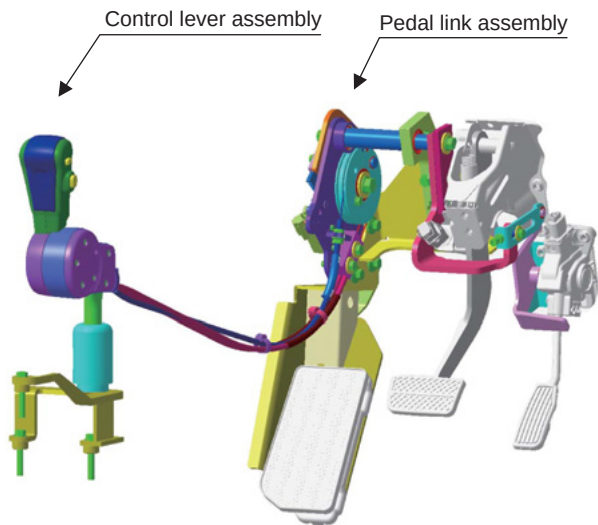


Fig. 3 New Honda Techmatic System



Fig. 4 Mock-up model

supports and houses the drive drum to which the control lever is attached. This secured strength and rigidity while also providing a high degree of shape freedom. The structure clasps these reinforcing parts between plastic cover sheets on both sides, and an elastic material (thermoplastic resin) was used in locations that might contact the user’s thighs and knees during driving.

The C. L. A. and the P. L. A. at the driver’s feet are connected by three cables and a wire harness inside polyester mesh covers, which provides a streamlined appearance for good product appeal. Figure 5 shows the device installed on an actual vehicle. These parts are all coordinated in basic black to blend with the cabin design and enable easy, lateral applications to various models.

3.1.2. Operating force transmission mechanism using three pull cables

The next matter to consider after the operation system had been decided was how to transmit the lever operating force to the pedal. Manually operated auxiliary driving devices are retrofitted to completed vehicles for which the package has already been decided, so mountability should be given sufficient consideration. The rod system, hydraulic system, and cable system were examined as media during the development stage, and eventually the cable system was adopted because it could achieve the purpose without mutual loss in operability, mountability, or safety reliability.

Thicker cables generally have an advantage in strength, but the allowable minimum bending radius also increases, thus imposing limitations on mounting layout. Therefore, to achieve a more compact structure, the high load during brake operation is constantly received by two $\phi 2.0$ mm-diameter twisted-pair cables made of stainless steel wire material via an equalizer. This approach secured sufficient strength, including durability, equal to or better than conventional approaches. In addition, the accelerator uses a single cable with the same specifications as the brake cables, but wired in the opposite direction of rotation. As



Fig. 5 Auxiliary driving device operated by hand (New type)

shown in Fig. 6, this cable layout is the same as the throttle forced return mechanism of a normal motorcycle. It allows direct input in the return direction using the lever, and even in the unlikely event of some malfunction in the accelerator linkage system, moving the lever in the brake direction would be certain to restore the accelerator.

3.1.3. Drum with built-in equalizer mechanism

The system is structured to transmit the brake operation load equally in the two cables by means of the equalizer. Even in the unlikely event that one brake cable breaks, therefore, the remaining cable would be certain to enable stopping.

The following matters were considered in designing the equalizer.

- (1) When the equalizer operates (when one cable has been severed), the remaining cable and the inner cable end should not be subject to excessive force.
- (2) The equalizer operation amount should be secured so that the driver can recognize the cable failure.
- (3) Compact

As shown in Fig. 7, a structure was devised to house the equalizer mechanism inside the drive drum in order to address these matters.

Figure 8 shows the equalizer in operation. The absence of a fixed rotating axis is a feature of this equalizer mechanism. In the event that one cable breaks, the cable-end connecting portion of the equalizer will move in a straight-line path along the side wall of the recessed space in the drum. This will cause the cable end to move 7 mm without adding any excessive force to the remaining cable. As a result, the invalid stroke amount on the control grip is 2.5 times or more the normal amount

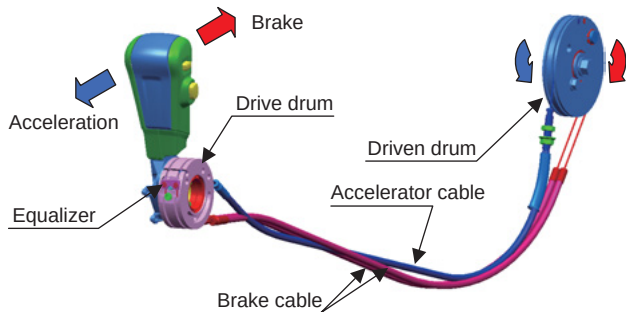


Fig. 6 Pull cables used for driving

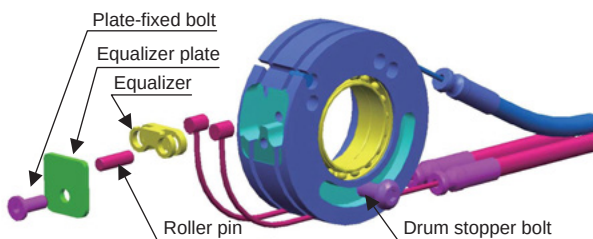


Fig. 7 Drum with built-in equalizer

of play, allowing the driver to recognize the malfunction.

In addition, an indicator was also installed on the top of the control lever housing, as shown in Fig. 9, to enable objective recognition of cable failure. The normal looseness on the indicator does not go past the ● mark, and in the event of a broken cable, it will exceed the range of looseness for two cables.

3.1.4. Switches built into grip

In driving operation with manually operated auxiliary driving devices, the right hand operates the steering wheel and the left hand operates both the accelerator-brake lever and the AT selector lever. This can sometimes make it a challenge to perform the various switch operations required for smooth and safe driving. To address this situation, the control grip of a manually operated auxiliary driving device should be equipped with auxiliary switches that have the equivalent functions to those of the base vehicle switches. The required auxiliary switches differ slightly among users, but the developed device was equipped with the following five switches to support as many users as possible (Fig. 10).

- (1) Brake lock
- (2) Turn signal
- (3) Horn
- (4) Headlight Hi/Lo-beam
- (5) Hazard

These switches basically made use of mass-produced car and motorcycle parts from the viewpoints of reliability and cost reduction. The brake lock switch (1) is unique

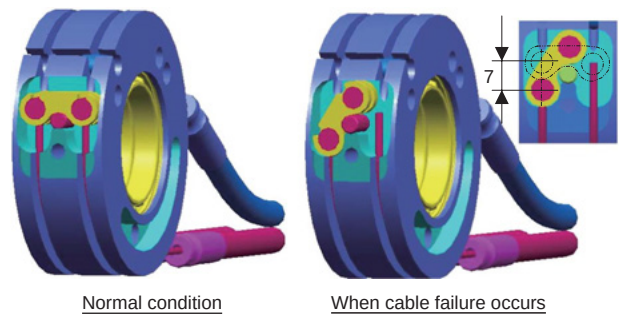


Fig. 8 Equalizer operation

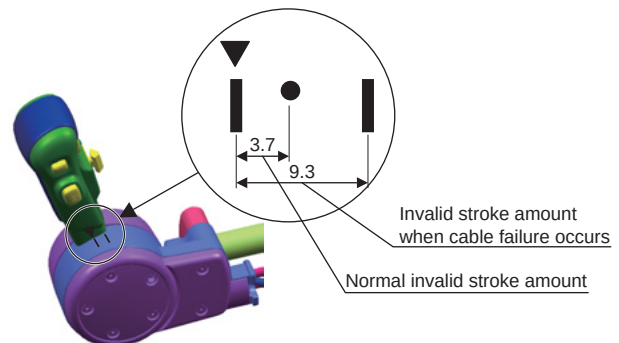


Fig. 9 Cable failure indicator

to manually operated auxiliary driving devices, and is not present on the base vehicle. This switch is indispensable, and is the most frequently used switch. When shifting the AT select lever from the P position to a different position, the select lever should be operated in the state with the brake pedal pressed. However, when using a manually operated auxiliary driving device, brake operations are performed by the left hand, which makes this a challenge. When the control lever is pressed to the brake side (towards the vehicle front) while pressing the brake lock switch, the brake pedal is held in the pressed state even when the user releases the control lever. This enables select lever operation.

As shown in Fig. 11, the five switches installed in the control grip and the wire harness added inside the instrument panel are connected by eleven low-voltage electrical wires (AVSSH0.3F⁽³⁾: super-thin wires for automotive use with nominal diameter of 0.3) inside corrugated tube with an inner diameter of 7 mm. To absorb harness movement due to accelerator and brake operations in the minimum space possible, the structure passes the wires through a space provided in the center of the control lever rotating part, and the harness bends (oscillates) within that space.

In addition, endurance testing was conducted to verify that the electrical wire had sufficient breaking resistance

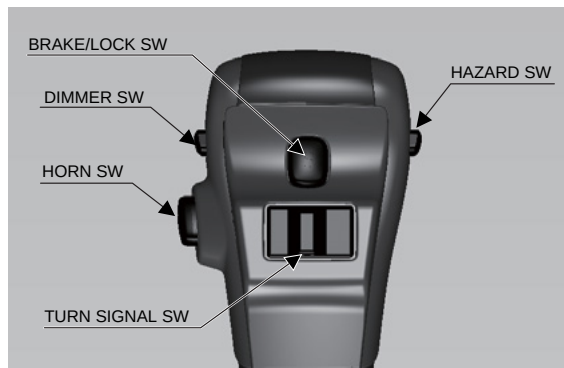


Fig. 10 Grip with built-in auxiliary switches

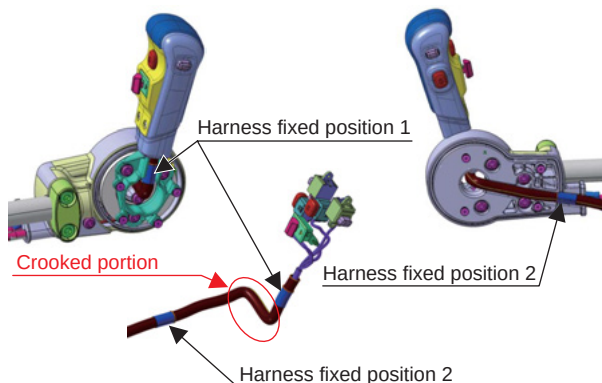


Fig. 11 Harness layout inside grip

with respect to bending (oscillation). The endurance testing was conducted in a mode that took frequency of use and other such factors into consideration by combining multiple operating angles, as well as a mode that considered low-temperature operating environments in which wire does not bend readily.

3.2. Pedal Link Assembly

The mechanism that embodies the single-axis short-lever system is the P.L.A. As shown in Fig. 12, the driven drum with an offset rotating axis and the cam plate are placed on either side of the main plate. Through the roller, the system converts the pulling force on the cable to rotary force on the main shaft.

The plate that is used at the point of contact between the cam plate and the roller is about one-fifth the thickness of plate that resists plastic deformation. This is based on “surface pressure design that takes into consideration work hardening due to plastic deformation,”⁽⁴⁾ whereby minute deformations (collapses) in the cam rolling contact surface are allowed. The width of the P. L. A. was thus reduced by the greatest extent feasible.

The brake lock mechanism described above is also incorporated into the P. L. A. The structure is shown in Fig. 13. Operation of the solenoid triggers the ratchet to

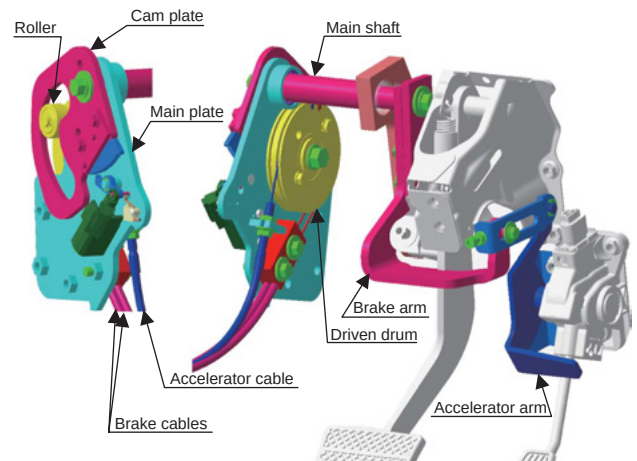


Fig. 12 P.L.A. (Pedal link assembly)

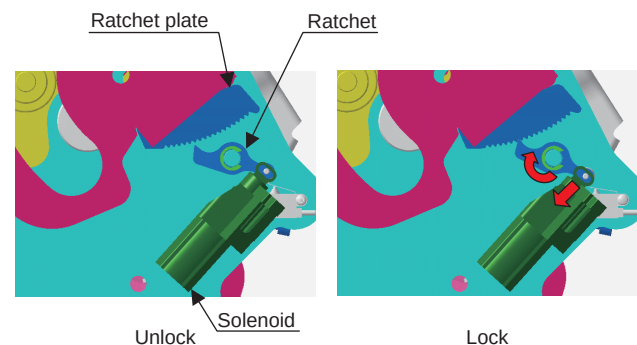


Fig. 13 Brake lock mechanism

rotate and engage the ratchet plate that is fixed in place on the cam plate, temporarily locking the main shaft so that it does not rotate. This serves to hold the brake pedal in the depressed state.

3.2.1. Operation Gain Variable Mechanism

Since the ordinary brake pedal secures a stroke double the normal operating range to cope with the failure of one of the hydraulic systems, the manually operated device should also secure a lever operating range that supports the failure of one of the hydraulic systems. However, the relationship between the lever stroke of conventional manually operated devices and the pedal stroke is determined by the geometry of the link mechanism, which comprises a rotating arm and rods. This made it a challenge to obtain the optimum characteristics over the entire stroke range.

Therefore, a gain variable mechanism that enables active setting of the operation gain (pedal stroke/lever stroke) was realized by the combination of the cam and roller. This allows further lowering of the small gain in the brake normal operating range to reduce the operation load, and increasing the gain to suppress the stroke over the operating range where the stroke increases due to failure of one of the hydraulic systems.

As shown in Fig. 14, the gain variable mechanism comprises an output axis (main shaft), an input axis (driven drum) located away from the output axis, and a roller located above the driven drum offset from the center. The input from the driven drum is output to the brake pedal rotating axis and the coaxial main shaft via the roller and the cam plate.

In a cable system, the number of parts can normally be reduced by locating the driven drum on the brake pedal rotating axis. When the device is actually mounted on a vehicle, however, the rigging of the brake cables can result in severe bending so that the sliding friction of the cables increases. The use of a cam and roller allows the

drum to be positioned lower down while at the same time enabling rotation of the drum to be reversed. As a result, the cables can be rigged to be closer to a straight line, which also contributes to lessening of the operation load and enhancement of cable endurance.

Figure 15 shows the operation gain characteristics chosen for the present device. The horizontal axis is the length of the arc of movement of the tip of the lever, which is taken as the lever stroke, and the vertical axis is the pedal stroke. On the right side of the neutral position, the brake characteristics are shown as a red line, and on the left side, the accelerator characteristics are shown as a blue line.

The brake characteristics include the pedal stroke divided into four regions that are indicated by different background colors. In order from the bottom, these are the normal braking region (light blue), the slam-on-the-brake region (yellow), the hydraulic one-line failure region (pink) and the brake fluid replacement region (lavender).

In the case of a drive drum with which the lever is fixed, the stroke is limited by the stopper bolt. The system was configured, however, so that the maximum pedal stroke would coincide with the maximum lever stroke.

The intermediate characteristics are lower gain and limited operation load in the normal operating region, and higher gain for limited stroke in the operating region where the stroke increases when one of the hydraulic systems fails.

The accelerator characteristics are set similarly so that the maximum pedal stroke coincides with the maximum lever stroke. In the normal operating range, the gain is reduced and the operation load is limited. In the operating range where the throttle is opened wide, the gain is increased and the stroke is limited.

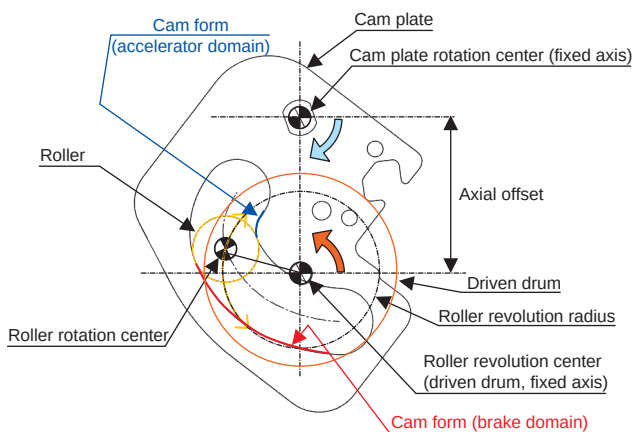


Fig. 14 Gain variable mechanism

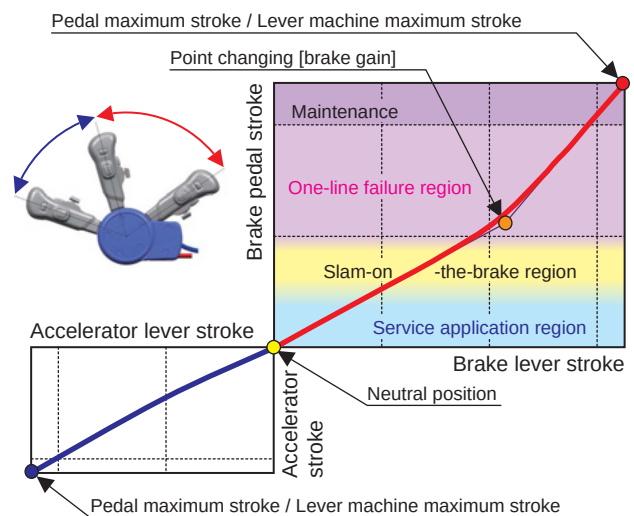


Fig. 15 Input/output characteristics

4. Verification on an Actual Vehicle

4.1. Operability

Figure 16 shows the lever stroke and load characteristics when the accelerator is operated. In order to minimize unnecessary play in the device as a whole, ball bearings were used on the main rotating axis. This enabled the position of Point A in Fig. 16, where the accelerator pedal starts to move, to be limited to 10 mm or less.

The distance to Point B shown in Fig. 17, where the brake pedal starts to move, was a similarly small 5 mm. This enabled smooth lever operation during continuous operation from one side of the neutral position to the other. It also allowed the load at Point A in Fig. 16 to be limited to 12 N or less and realized characteristics equivalent to those of the accelerator pedal on the base vehicle.

The brake operation characteristics shown in Fig. 17 allow the driver to clearly perceive Point C, where the brakes actually become effective. The driver can control braking from that point while receiving a definite sense of tactile response in the lever. This yielded operation feeling equivalent to that of the base vehicle.

To enable users to “enjoy driving,” it is considered essential to set the proper load and hysteresis for controls,

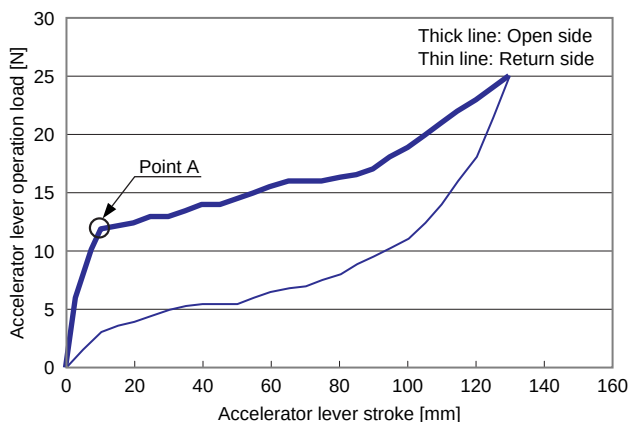


Fig. 16 Accelerator operation characteristics

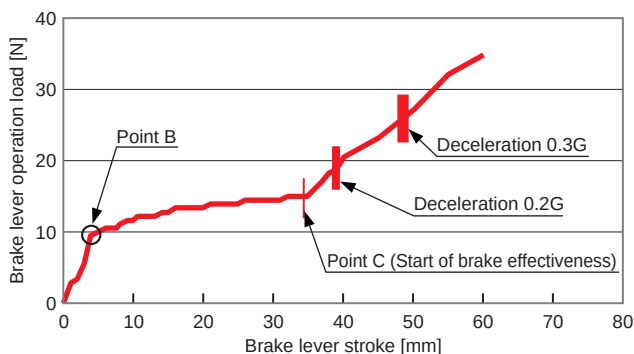


Fig. 17 Brake operation characteristics

and to minimize unnecessary motion. Cables and a gain variable mechanism were selected as the means of achieving this, and realized a direct sensation as though the driver were pressing directly on the pedal.

4.2. Mountability

The manually operated auxiliary driving device here was developed on the assumption that it would be mounted on vehicles by dealers. In order to secure assembly reliability at the dealers, therefore, it was decided to ship the system with the C. L. A., the P. L. A., and the cables already assembled and with the tension in the cables adjusted in advance.

Installation of the parts makes use of existing attachment points, requiring no new holes to be opened in the vehicle at the dealer. Further measures, such as the use of protective members, were also taken to prevent damage to the cables.

Figure 18 is a diagram of the system assembled and mounted on a vehicle. The only parts that have to be removed once before installing the system are the center console and other such resin parts.

These measures yielded a reduction of approximately 20% in installation labor compared to Honda's conventional product.

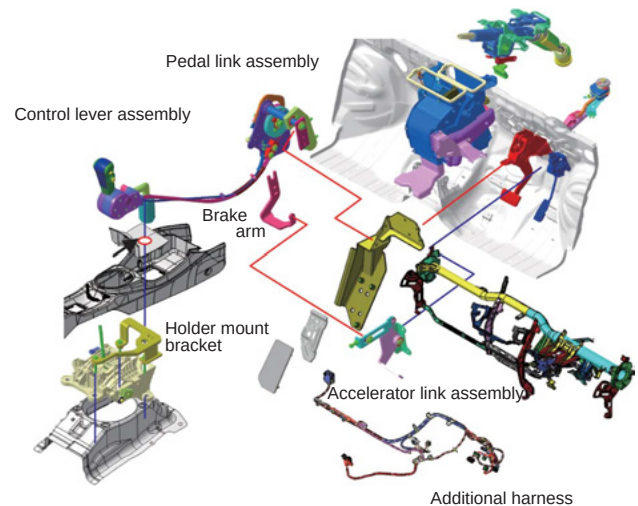


Fig. 18 Construction of New Honda Techmatic System

5. Conclusion

A new manually operated auxiliary driving device was developed and mounted on the FIT.

Safety and reliability as official Honda product features have been secured, and in terms of operability, major advances from just “the ability to drive” to “enjoying driving (Fun for Everyone)” were made, and the system is now compatible with various car models and is easy to install as well.

The authors are confident that the many features not previously available will delight an even greater number of customers.

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