

Introduction of Product

Introduction of GD755/GH320 GALEO Series Snow-Removal Motor Graders

Shinji Iguchi

GD705A-4A snow removal motor grader, which has been marketed since 1983, and GH320-2 high-speed compacted-snow removal grader, which was developed and marketed after 5 years of joint study as a development project of the Ministry of Construction that started in 1990, were fully model-changed after 22 years and 15 years, respectively, to incorporate advanced technologies and thus meet the needs of new age. They are marketed as models GD755-3 and GH320-3. This report introduces these new models.

Key Words: Motor Grader, GD755, GH320, Snow Removal, Product Introduction, Snow Removal Attachment, Variable Horsepower, Dual Mode Transmission, Tier2 Emissions Regulation, CLSS Hydraulic System, Hydraulic Control Brake System, Steering System with Quantity Amplifier

1. Introduction

Komatsu GD700 Series (blade length 4 m class) motor grader shares almost 100% in the snow removal conducted by government agencies in Japan, fulfilling the social mission of securing the means of transportation in winter as the principal machines for snow removal of roads.

Though Japanese market is not so large, i.e. approximately 70 units per year, it is indispensable for DB including the sale of spare parts and is highly reputed by government agencies.

Taking the opportunity of complying with Tier II emissions regulation, Komatsu developed new models that incorporate new features to meet the needs of new age. Following are the overview of the new models (**Photo 1**).



Photo 1 GD755 Overall view

2. Development Concept

Concerning quality, medium size GXX series motor graders (GD655/GD675/GD555) are already at the highest level in the world, and their development concept was applied also to the new models.

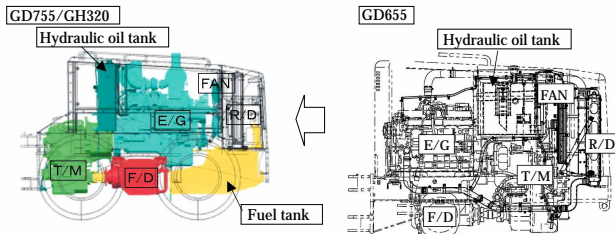
However, because of full model change after 20 years, there was a problem of how to minimize the increase of cost, which is resulted from increasing the performance, and provide new models at reasonable prices.

Our basic concepts are as follows:

- (1) Compliance with Tier II-emissions regulation
Environment-friendly clean engine and low noise
- (2) Improved operability
Easy operation by automatic transmission (automatic gear shifting)
- (3) Improved work performance
Increased operation speed by variable horsepower
- (4) Measures to improve reliability and safety
Full hydraulic control brake system, O-ring face seal, the employment of DT connector, emergency steering as standard
- (5) Improved maintainability and serviceability
Employment of machine monitoring system, the extended engine oil change interval, and provision of KOMTRAX as option
- (6) A wide variety of snow removal attachment
A wide variety of snow removal attachment that meets the snow quality of individual district

In order to minimize the increase of cost, unlike medium size models, the power train was configured such that the transmission is arranged at frontward portion of the machine to simplify the system configuration.

As a result, it became possible to install a large fuel tank (416 liter) at lower portion of the machine, which facilitates the refilling of fuel (Fig. 1).



Though the same concept of medium size GXX is applied, the power train configuration is changed such that transmission is arranged at frontward portion of the machine (for medium size, arranged at rearward portion) to simplify the configuration and enable refilling fuel by standing on the ground.

Fig. 1 Comparison of power train configuration

To improve safety during on-road traveling, the brake control system was changed from pneumatic to full hydraulic control type, and O-ring face seal was employed for the hydraulic piping.

To meet the demand for high-speed snow removal, GD755 employs the variable horsepower (VHP) system to improve snow removal performance to a large extent, compared with conventional models.

Especially advanced is the technology of automatic transmission and direct drive /torque converter mode selection that uses a transmission with lockup torque converter.

The system that allows operator to freely select between direct drive and torque converter modes is the unique technology that no company other than Komatsu possesses in the world.

3. Main Features

3.1. Compliance with Tier II emissions regulation

3.1.1 SAA6D125E-3 engine is installed to comply with Tier II emissions regulation

(1) SAA6D125E-3 engine, which is equipped with a large capacity fuel feed pump, is installed to comply with Tier II emissions regulation and improve serviceability.

In addition, for GD755, two types of horsepower curve (220 HP and 250 HP) are incorporated in the engine controller to implement VHP.

(2) The engines of GD755 and GH320 are configured with the same application to facilitate interchangeability.

3.2 Improved operability

3.2.1 Employment of transmission with lockup torque converter

(1) Under the same concept as medium size GXX series, the transmission with lockup torque converter that is already highly reputed in the USA market is installed (Fig. 2).

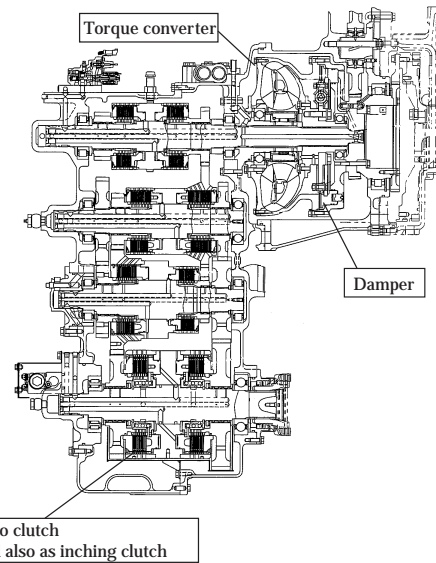


Fig. 2 8th speed transmission with lock-up torque converter

Concerning the transmission of motor grader, European machines employ torque converter system while USA and Japanese machines employ direct drive system.

There are arguments pro and con regarding which of the two systems excels in operability. So, for GXX series, it was made possible to change over between torque converter and direct drive modes.

In Japan, experienced operators tend to prefer direct drive mode, while young operators prefer torque converter mode. Concerning snow removal, the operators who operate only in winter (for 3 months) are increasing. So, torque converter system, which is easy to operate, is advantageous.

For this time model change, "improved operability" of transmission is the key of our "unique and unrivaled product".

(2) In torque converter mode, medium- and higher speed stages are made to have the automatic gear shift function to relieve the fatigue of operator during snow removal.

Operator will be tired out if he must perform both complicated blade control and transmission control on a road on which many ordinary vehicles run (Fig. 3).

Torque converter mode and automatic gear shift function relieve the operators' work of transmission control and thus improve safety.

Operator not only operates the travel lever but also controls individual actuator according to road condition.

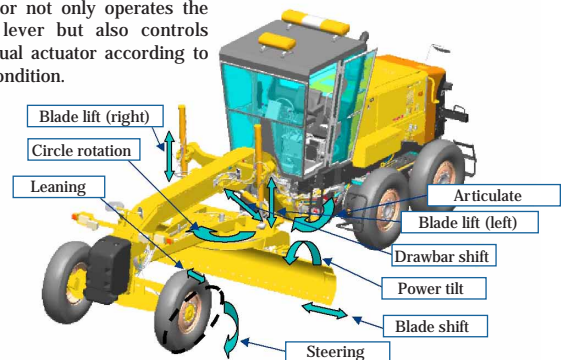


Fig. 3 Grader operation

(3) A mechanical damper is built in the transmission. For this, Komatsu developed a unique damper and incorporated it in the transmission.

Because backbone type, which directly connects engine to transmission, is employed, mechanical damper is used to improve reliability, taking the temperature rise in the housing into consideration.

3.2.2 Hydraulic system

(1) The integrated CLSS system, which controls blade, brake and steering by a single variable displacement piston pump, is employed (Fig. 4)

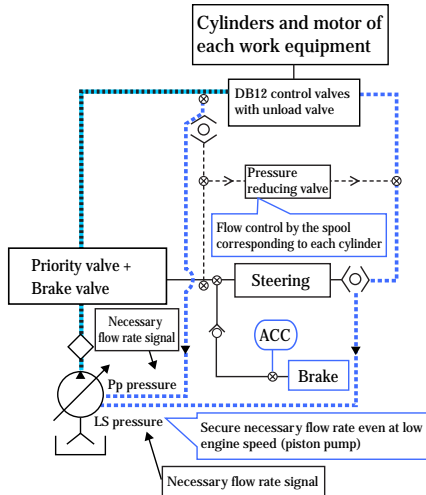


Fig. 4 Hydraulic system

With conventional models, because gear pump is used, the speed of blade greatly changes with engine speed. For the new models, because the speed change of blade is limited, from low to high engine speed, by means of piston pump, operators can control blade with the same feeling throughout the work. Thus easy operation is achieved (Fig. 5).

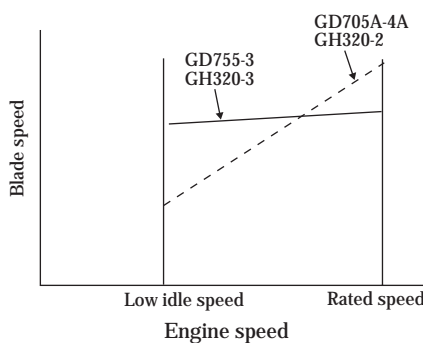


Fig. 5 Work equipment speed

(2) The opening area of DB12 control valves is made proportional to the areas of cylinder head and bottom to keep the speed of blade constant, from low to high engine speed. In addition, the constant ratio flow dividing function assures that downstream side control valve is surely operated also when multiple blade control levers are operated simultaneously. Thus, the operators who work only in winter

as described before can remember the knacks of operation in a short time.

3.2.3 Reduction of noise in operator cab

Front frame mounted cab is employed to separate the cab from engine room, transmission and hydraulic pump and thus reduce the noise level in the operator cab (Fig. 6)

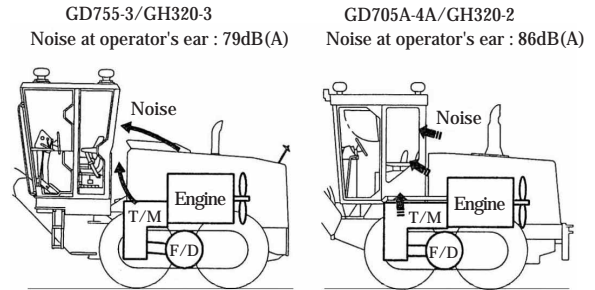


Fig. 6 Noise level in cab

3.2.4 Improved front/working visibility

GXX cab with large glass area is employed to improve visibility by 15% (Fig. 7).

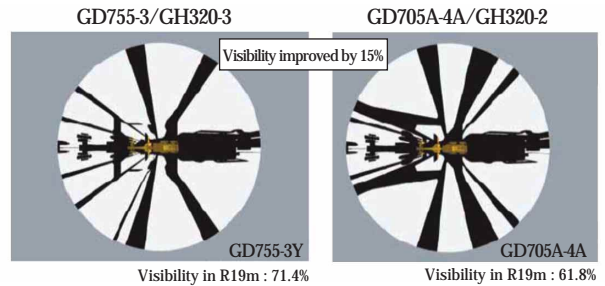


Fig. 7 Comparison of visibility



Photo 2 GXX cab

3.3 Improved working performance

**3.3.1 Variable horsepower (VHP) GD755
(Fixed horsepower for GH320)**

For the purposes of reducing fuel consumption and extending the service life of tire, variable horsepower is employed for GD755.

The engine controller has two horsepower curves, or Hi (250 HP) and Lo (220 HP), and select the Lo curve for low travel speed stages and the Hi curve for high travel speed stages through interaction with the transmission controller.

The curve for low travel speed stages aims at reducing fuel consumption and the wear of tire due to slip.

The curve for high travel speed stages aims at improving snow removal speed to increase production as well as improving acceleration performance when traveling between job sites. (For details regarding variable horsepower, refer to the "Introduction of Product : GD655", KOMATSU TECHNICAL REPORT, January 2001.)

Fig. 8 shows the result of the snow removal type test that was performed by the Japan Construction Mechanization Association in Ebetsu City in Hokkaido. Compared with conventional model GD705A, GD755 showed 1.4 times higher snow removal performance.

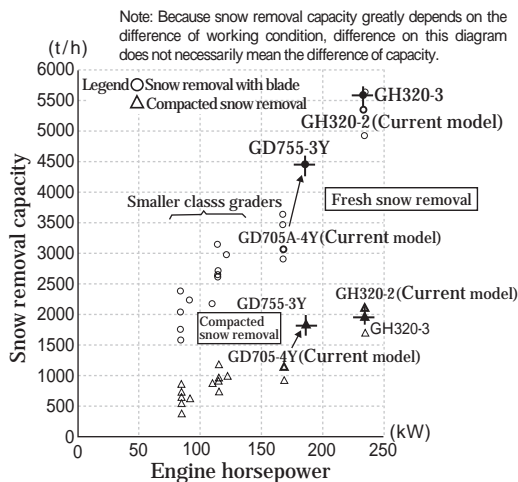


Fig. 8 Snow-removal capacity

3.4 Measures to improve reliability and safety

3.4.1 Brake control system

Full hydraulic control brake system is employed to improve reliability and maintainability.

While conventional models use pneumatic control system, for the model-changed machines, full hydraulic control brake system is employed.

With pneumatic control system, even if a dryer is equipped, it is inevitable that dew condensation in piping and dust contained in the air have an influence on equipment.

Using full hydraulic control system, we succeeded in improving the reliability of equipment and relieving the work necessary for tank internal maintenance.

3.4.2 Fuel tank

Fuel tank is arranged at lower portion of the rear frame to enable the refilling of fuel by standing on the ground, taking the safety during refilling into consideration (**Fig. 9**).

With conventional models, it is necessary for operator to ride on the tandem drive case with the nozzle in hand to refill fuel. However, the tandem drive case easily gathers snow or mud, which freezes in winter to cause the danger of operator's slipping. The refilling by standing on the ground assures the safety during refilling.

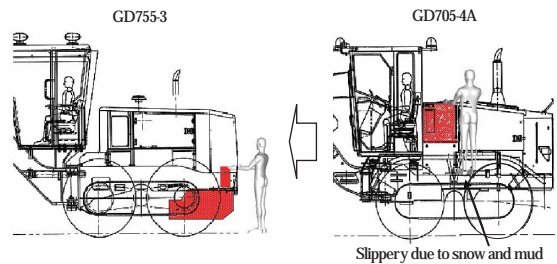


Fig. 9 Comparison of fuel refilling

3.4.3 Emergency steering

Orbit-roll with quantity amplifier is employed to enable temporarily steering if engine stops (**Fig. 10**).

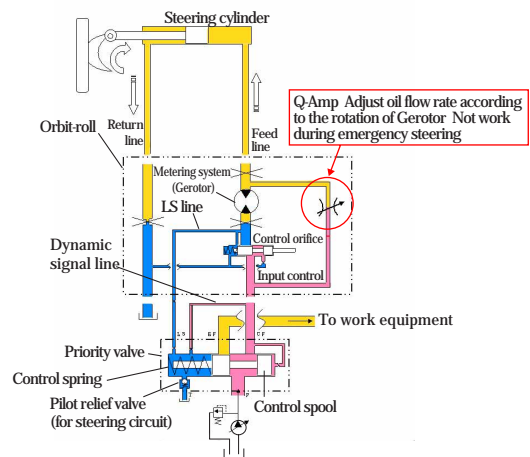


Fig. 10 GD755/GH320 steering circuit

During normal operation, the Q-Amp circuit amplifies according to the rotation of the Gerotor of the orbit-roll to supply necessary flow rate to the system.

On emergency, steering is controlled by the flow rate supplied from the Gerotor.

3.4.4 Other measures

(1) O-ring face seal is employed in the hydraulic system. No oil must leak onto the road on which ordinary vehicles run. To assure this, seal was changed to O-ring face seal to further improve reliability.

(2) DT connector employed in electrical systems. To minimize the influence of snow-melting chemicals spread on the road or the snow fumed up in the air, DT connector with high sealing property is employed.

3.5 Improved maintainability and serviceability

3.5.1 Machine monitoring system

A 16-digit x 2-line machine monitoring panel is arranged in the steering post panel to improve maintainability (**Photo 3**).

<Items displayed>

- (1) Service meter and cumulative running distance
- (2) Action code display
 - Machine condition / Instruction of maintenance
- (3) Error code display
- (4) Service function
 - Real-time monitor
 - Engine cylinder reduction mode
 - Adjusting function
 - Option selecting function
 - Forcible low idle fixing function
 - Torque converter stall function



Photo 3 Monitor panel

3.5.2 KOMTRAX

Because individual regional maintenance offices of the Ministry of National Land and Transport have their own operation management system, KOMTRAX was made to be an option.

3.6 A wide variety of snow removal attachment (option)

3.6.1 Combined automatic blade control

The combined automatic blade control system, which automatically controls the blade cutting angle and blade lift cylinder force according to the information sent from the vibration sensor mounted on blade so that no residual snow is left on road and maximum efficiency is achieved, is provided as an option (**Fig. 11**).

(For details regarding the system, refer to KOMATSU TECHNICAL REPORT, February 2002.)

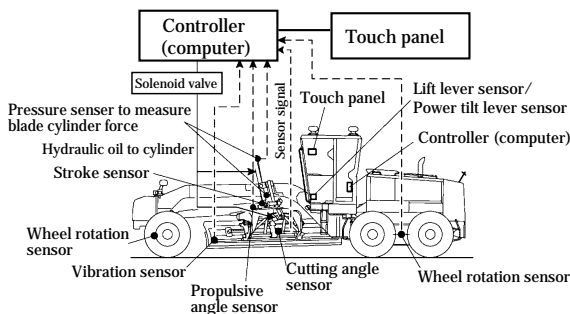


Fig. 11 Combined automatic blade control

Fig. 12 shows how many times an operators operates the blade control levers during snow removal work. Most of the operations done are the lifting and lowering of blade. It is clear from this graph that the load of operator will be greatly relieved if this operation is automated. This system eliminates the left/right blade lift/lower operation, relieving the fatigue of operator and improving the efficiency of snow removal.

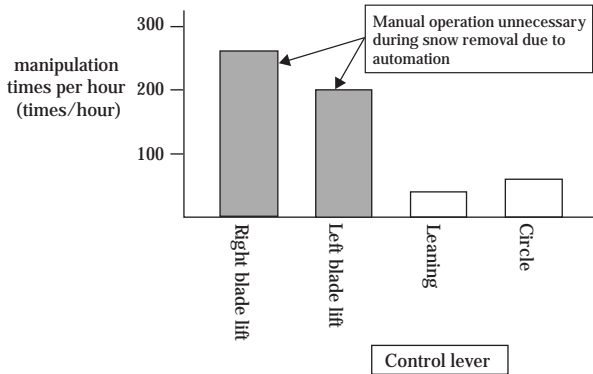


Fig. 12 Manipulation times per snow-removing hours

Fig. 13 shows the result of operation survey that was performed in Hokuriku district. It was reported that work speed increased by 18% compared with manual blade control, and by 7% compared with conventional blade control (with the system described in 3.6.7)

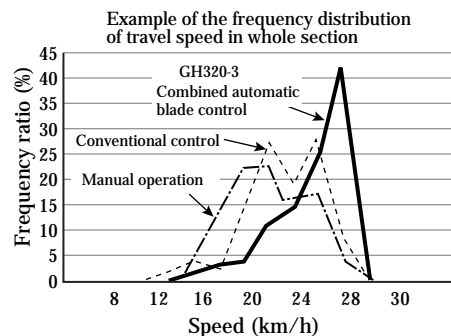


Fig. 13 Example of improved work speed with combined automatic blade control

3.6.2 Moldboard high-impact load relief device (Fig. 14)

During snow removal work, blades sometimes come in contact with structures existing on road (manhole, bridge joint, pavement curbstone, etc.)

In general, the shear pin or the clutch that is installed in the circle drive unit is released to free the circle unit and thus relieves the impact load. However, the impact load applied on the center portion of blade may not fully be relieved by the rotation of the circle to result in damaging the machine.

This system makes the circle unit jump up in the direction of upper rear to relieve the impact load if a structure collides with the center portion of blade.

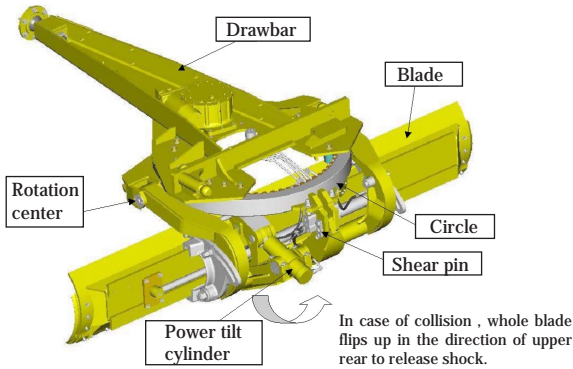


Fig. 14 Moldboard high-impact load relief device

3.6.3 Tandem moldboards device (Fig. 15)

Many of high-standard roads often have the crossing with right-turn dedicated lane. At such crossings, the width of snow removal increases, and all snow cannot be removed by one pass. Therefore, a grader needs to run to and fro several times to remove snow. Or a grader is operated in pair with a snow removal wheel loader, while entrusting the snow removal of crossing entirely to the loader. This system has two blades to increase the width of snow removal by stretching them left- and rightward when it is necessary to remove snow in a wide area and reduce operation time.

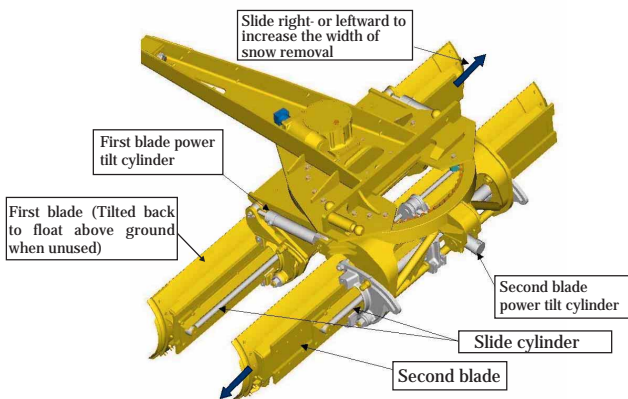


Fig. 15 Tandem moldboard device

3.6.4 Circle drive slip clutch (Fig. 16)

This unit releases the large load or shock that is applied to the end portion of blade by allowing the circle to rotate in the direction that relieves the load or impact in order to protect the operator and the machine.

Compared with the shear pin type circle drive unit, the clutch type circle drive unit has the following advantages:

1) Though the circle rotates when a large impact or load is applied to relieve the impact or load, it stops rotating the moment the shock or load is released and returns to the original position, so that the probability of the blade's damaging the rear tire or tire guard due to the reaction that occurs when the shear pin is cut, etc. is low, compared with shear pin type.

2) Because the circle automatically returns to its original position after the shock is released, it is unnecessary to replace the shear pin of the circle drive unit in cold wind while regulating the traffic of public road.

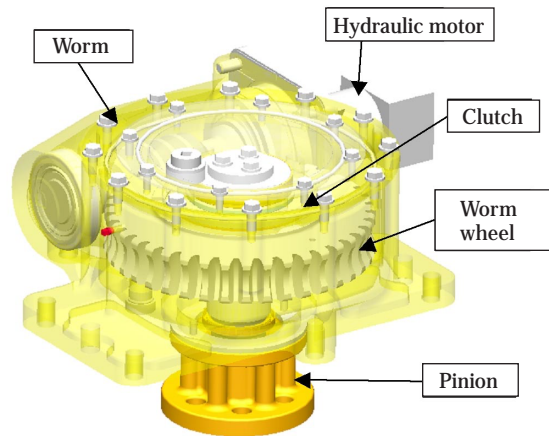


Fig. 16 Circle drive slip clutch

3.6.5 Blade float (Fig. 17)

In removing fresh snow, it is unnecessary to use strong blade lift cylinder force. Snow can be removed only with the dead weight of blade. With the blade float system, only the dead weight of blade (3 ton) is used to remove snow, making it unnecessary for operator to lift or lower the blade. Thus snow can be removed efficiently. However, this system is effective only with fresh snow and not so effective with hard snow that is compacted by running vehicles.

3.6.6 Blade lift accumulators (Fig. 17)

This system holds blade lift cylinder force while removing compacted snow to reduce the number of operation times of the blade lift/lower lever and thus improve the efficiency of snow removal. When this system is activated after appropriate blade load for snow removal is obtained with the lift/lower lever, the blade load is held. What you have to do after that is only increase or decrease the load with the lift/lower lever while observing the condition of snow removal. The system automatically follows up the ruts of road (unevenness of pedestrian crossing).

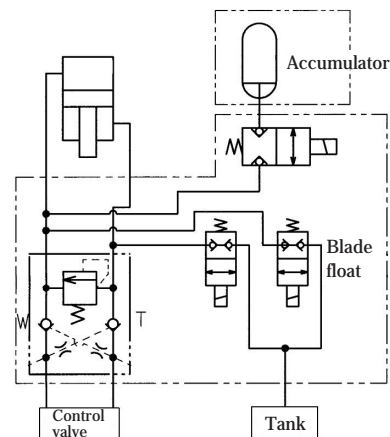


Fig. 17 Blade accumulator and blade float

3.6.7 Automatic blade control system

The new models have also the function that is similar to above explained 1) combined automatic blade control system and 2) blade lift accumulators. Its difference from the combined automatic blade control is that only blade lift cylinder force is controlled by the lift cylinder and the blade cutting angle is not controlled at all.

While the blade complex automatic control aims at increasing the speed of snow removal by achieving an efficient cutting angle and thus relieving the load of snow removal, the blade automatic control is specialized in preventing the uneven wear of edge by controlling the load that is applied on the left and right of blade independent of operator's skill as well as holding the optimum blade line pressure, among various features of the blade complex automatic control.

3.6.8 Surface roughening device (from Iwasaki Kogyo, Photo 4)

The surface roughening device from the attachment manufacturer can be installed. This device flaws the road surface after snow removal with blades, which often becomes specular, so that succeeding vehicles won't slip. In general, it is mounted on the rear of machine and operated while snow is removed by blades.



Photo. 4 Surface roughening device

3.6.9 Windrow shutter device (from Iwasaki Kogyo, Kyowa Kikai Kogyo, Photo 5)

The windrow shutter device from the attachment manufacturers can be installed. This device temporarily stops the discharge of snow to prevent the windrow of removed snow from being remained at crossing or near the entrance of houses.

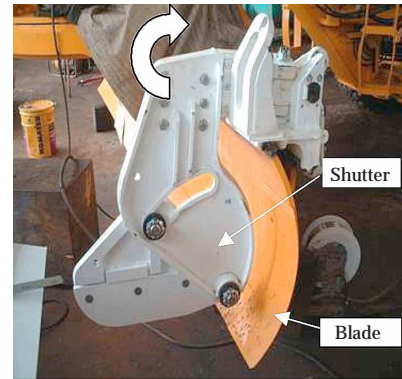


Photo 5 Windrow shutter blade

3.6.10 Power tilt

This system changes the cutting angle of blade according to the condition of snow. In general, for hard compacted snow, blade is raised to raise the edge and thus more deeply penetrate into the snow. On the other hand, when the blade is laid more horizontal, snow is removed more efficiently and the speed of snow removal increases.

3.6.11 Blade for the Development Bureau (GH320)

The quality of snow differs with districts. For example, in the Hokuriku district, wet heavy snow falls while in Hokkaido light powder snow falls.

For snow removal, how snow rolls up in the blade changes with the quality of snow. Especially when powder snow overflows the blade, it obstructs front visibility.

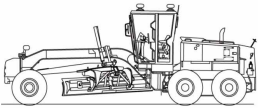
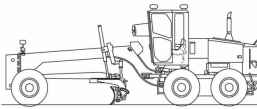
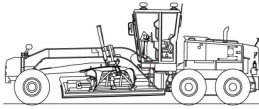
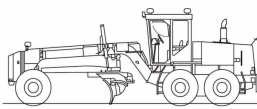
For GH320 that was developed for high-speed snow removal, special blades that are best suited to individual district are prepared for the Development Bureau.

3.6.12 Other main attachments and options

- (1) Large capacity heater: 800 kcal
- (2) Lock/unlock differential
- (3) Bank cut device
- (4) Large capacity alternator (140A) and battery (C200)

4. Conclusion

There are three main markets for GD755 class motor grader in the world, i.e. USA, the Middle and Near East and Japan. Though presently marketed only in Japan, GD755 has high quality to compete with rivals in the world. We will make further efforts so that the product will be reputed by the users not only in Japan but also worldwide as early as possible.

Model	GD755-3Y	GD705A-4A(Conventional model)	GH320-3	GH320-2(Conventional model)
Item				
Engine	SAA6D125E-3 164 - 186kW(223 - 254PS) Variable output (variable horsepower) Comply to the Tier2 emissions regulation	S6D125E-2-A 169kW(230PS) Fixed output, Comply to the Tier1 emission regulation	SAA6D125E-3 235kW(320PS) Fixed output, Comply to the Tier2 emissions regulation	S6D125E-2-A 235kW(320PS) Fixed output, Comply to the Tier1 emission regulation
Transmission	F8R8, Counter-shaft type, automatic transmission, with lock up T/C, electronic control (ECMV)	F8/R8, planet gear type, mechanical control (automatic transmission, electronic control can be installed in factory as OPT)	F8R8, Counter-shaft type, automatic transmission, with lock up T/C, electronic control (ECMV)	F7/R8, planet gear type, mechanical control (automatic transmission, electronic control can be installed in factory as OPT)
Final drive	Single shaft without differential (Opt : Lock/Unlock differential)	Single shaft no-spin	Single shaft without differential (Opt : Lock/Unlock differential)	Single shaft no-spin
Service brake	Wet disk, full hydraulic type	Wet disk, air control type	Wet disk, full hydraulic type	Dry drum, air over hydraulic type
Parking brake	Dry disk, Spring actuated, hydraulically released	Internal expanding mechanical type	Dry disk, Spring actuated, hydraulically released	Internal expanding mechanical type
Hydraulic system	CLSS, piston pump	Conventional gear pump	CLSS, piston pump	Conventional gear pump
Electrical system	T/M controller, E/G controller	No controller	T/M controller, E/G controller	No controller
Brake control	Full hydraulic control	Air brake control	Full hydraulic control	Air over hydraulic control
Operation of parking brake	Electronic control	Mechanically operated (by cable)	Electronic control	Mechanically operated (by cable)
Cab floor	Front frame mounted	Rear frame mounted	Front frame mounted	Rear frame mounted
Cab	Square cab	Hexagon cab	Square cab	Hexagon cab
Work equipment	Combined automatic blade control system (OPT) Blade automatic control system (OPT)	Blade automatic control system (OPT)	Combined automatic blade control system (OPT) Blade automatic control system (OPT)	Combined automatic blade control system (OPT) Blade automatic control system (STD)
Fuel tank installation position	Lower portion of rear frame (refilling by standing on the ground)	Between engine room and cab (refilled by riding on the tandem)	Lower portion of rear frame (refilling by standing on the ground)	Lower portion of rear frame (refilling by standing on the ground)
Others	Car inspection adapted parts as STD, tire guard, rear under mirror/ front left/right mirror as STD Electric system : DT connector Hydraulic piping: O-ring face seal	Car inspection adapted parts as STD, tire guard, rear under mirror/ front left/right mirror as STD Electrical system : X. SWP connector Hydraulic piping: Taper seal	Car inspection adapted parts as STD, tire guard, rear under mirror/ front left/right mirror as STD Electric system : DT connector Hydraulic piping: O-ring face seal	Car inspection adapted parts as STD, tire guard, rear under mirror/ front left/right mirror as STD Electrical system : X. SWP connector Hydraulic piping: Taper seal

Introduction of the writer



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Entered Komatsu-Zoki in 1981.
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[A few words from the writer]

We have progressed with the development in a tight schedule because if the development should be delayed and the one year's grace for the Tier II emissions regulation in Japan should expire, it would become impossible to receive the snow removal type test in winter and publicize the inspection sticker throughout Japan before sales is started. Every night I had a bad dream of schedule to wake up pale. Though the development itself was hard, I am pleased with the high-quality result and wish to thank all related persons for their hearty cooperation.