Introduction of the "ARION Plus", Battery Powered, 4-Wheel Forklift Truck

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People in this country are growing increasingly conscious of global ecology, as disruption of nature continues and environmental problems become more and more pronounced. Turning our attention to the market of forklift trucks, meanwhile, customers are heightening their cost consciousness and are highly critical not only of the initial cost but also of the repair and maintenance costs of their forklift trucks. Against such a social backdrop, battery powered forklift trucks without gas emissions and noise are rapidly replacing the conventional combustion engine powered forklift trucks that in the past have accounted for more than half the total market. However, battery powered forklift trucks in general have been inferior to the engine powered type in terms of horsepower and continuous operating time, which has necessarily limited the range of potential users.

In response to this assessment our ARION Plus Series has been developed to better address the shortcomings of previous battery powered forklift trucks. They compare favorably with the engine powered type in terms of horsepower and yet maintain the characteristics inherent in the battery powered type, i.e. "clean and noise-free" In this thesis, we will summarize the features of the ARION Plus Series.

***Key Words**: Ecology, Environmental Problem, Battery Powered Forklift Truck, Maintenance-free, Repair and Maintenance Cost*

1. Introduction

1.1 Market trend

The demand in Japan's domestic market for battery powered forklift trucks is increasing year by year, accounting for more than 40% of the market share in 2001. (See **Fig. 1**) Forklift trucks are classified into three kinds, i.e. counterbalance type, reach type and walker type. In the domestic market, the first two types are the mainstream models and their numbers are rapidly increasing (See **Table 1**). Their growing popularity in the world is largely explained by customers' concern for the environment, protection of their employees against the noise and vibration from engine powered trucks and a desire to elevate their practices to the levels of the developed countries of Europe and the US. Thus customers are moving away from the traditional engine powered (particularly gasoline engine powered) forklift trucks, which accounted for over 50% of the total market. (See **Fig. 2**)

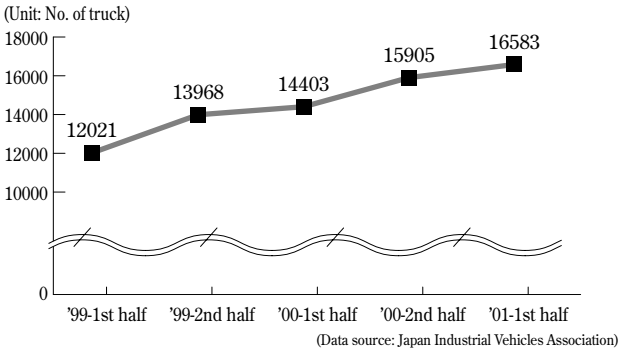
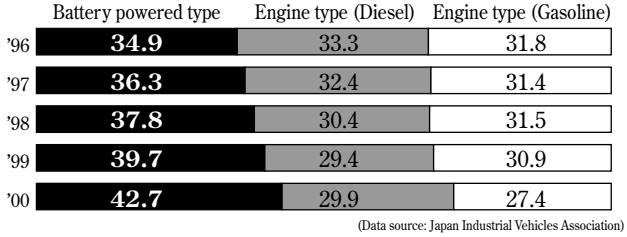


Fig. 1 History of demand for battery powered forklift trucks in Japan's market

Table 1 History of battery powered forklift trucks by type delivered in Japan's market (Unit: No. of truck)

	'98	'99	'00
Walker (Pedestrian) type	530	494	598
Reach type	11,535	11,383	13,693
Counterbalance type	12,518	13,428	15,258

(Data source: Japan Industrial Vehicles Association)



(Data source: Japan Industrial Vehicles Association)

Fig. 2 History and breakdown of forklift trucks by prime mover delivered in Japan's market (Unit: %)

What are the situations outside of Japan in this regard? In Europe, where an assortment of stringent policies are universally applied to alleviate environmental problems, the battery powered type has long exceeded 50% of the market, while in the US, the battery to engine ratio remains almost equal, similar to the case in Japan. From now on, however, there is no doubt but what the market share of battery powered forklift trucks will continue to increase in both countries.

On the other hand, in the market for engine powered forklift trucks, compact size trucks and CNG (compressed natural gas) powered trucks are being aggressively introduced, encroaching the traditional market for battery powered forklift trucks. (See **Fig. 3**)

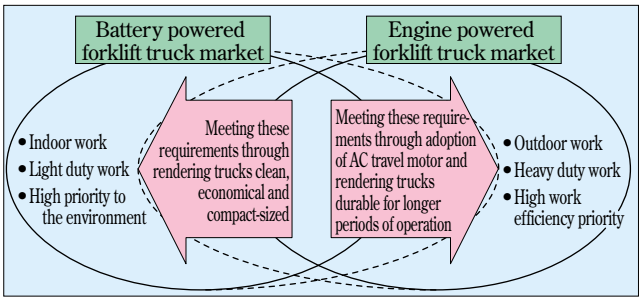


Fig. 3 Forklift truck market trend

1.2 Features of counterbalance type battery powered forklift trucks

A counterbalance type, battery powered forklift truck is composed of a chargeable lead storage battery (predominantly 48 VDC type), travel motor, work equipment motor that drives a hydraulic pump for material-handling devices and a steering motor plus a controller that serves to control each motor. (See **Fig. 4**)

When contrasted with the engine type, the battery powered type possesses such advantages as economy, compactness, low noise, low vibration and no emissions. But it also has disadvantages, like a shorter continuous operating time and inferior travel performance. (See **Fig. 5**) With these advantages and disadvantage taken into consideration, the demand for battery powered lift trucks has mainly centered on industries involving indoor handling of foodstuffs and relatively light duty material handling in warehousing as well as transportation. (See **Table 2**) Although they require powerful lift trucks contrary to this concept, additional large sources of demand for battery powered type lift trucks are the paper manufacturing and housing material industries.

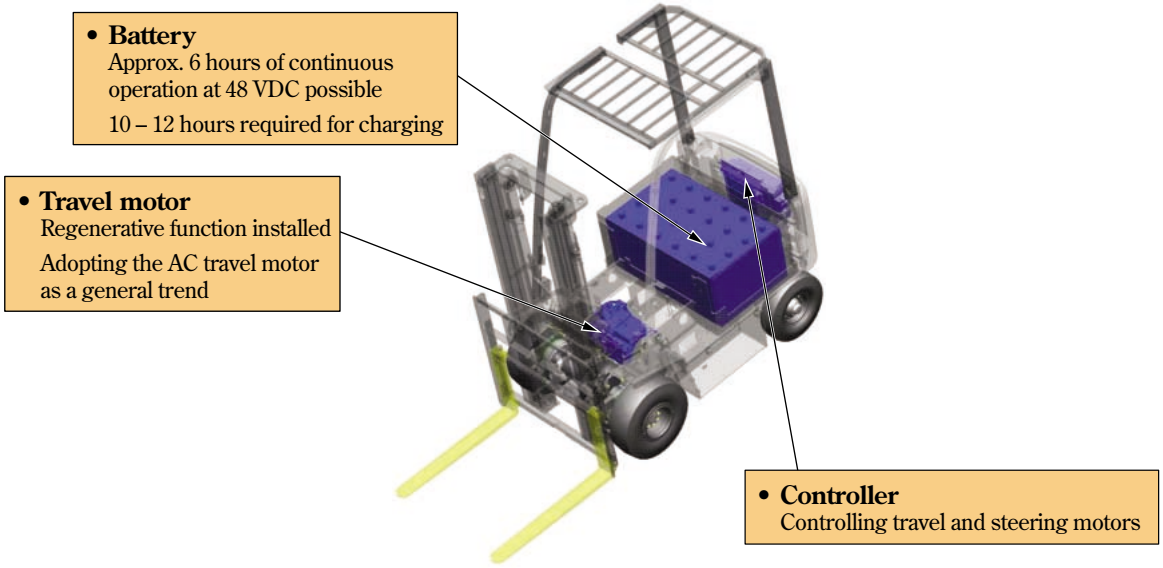
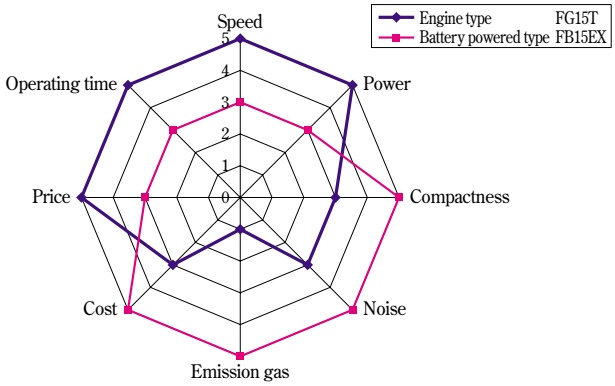


Fig. 4 Structure of a battery powered forklift truck



Comparison Item	Major Indicator	Unit	Engine type	Battery powered type
			FG15T	FB15EX
Speed	Travel speed	km/h	19	15.5
Power	Traction force	kgf	1050	900
Compactness	Turning radius	mm	1955	1760
Noise	Noise level at operator's ear	dB(A)	80	67
Emission gas	CO emission	%	1 – 2	0
Cost	Running cost	—	6.05	1
Price	Initial cost	—	1	1.44
Operating time	Continuous operating time	—	1 – 2 days with fuel tank completely filled	5 – 6 hours per charge

Fig. 5 Characteristics of battery powered forklift trucks (Compared with engine type)

In the course of developing our forklift trucks of the ARION Plus Series, we have upheld the objective that they demonstrate high power, comparable to that of the engine type, while maintaining the features inherent in the battery powered type. In the end, our efforts resulted in a product that achieved a 10% increase in travel speed and a 26% increase in gradability as compared with the equivalent engine type. We will introduce a summary of development activities in the following chapter.

Table 2 History of sales of forklift trucks by prime mover and by industry (%)

Order (in descending order of %) \ By prime mover	Battery powered type						Engine type					
	1998		1999		2000		1998		1999		2000	
1	Foodstuff	(15.1)	Foodstuff	(17.0)	Transport	(15.4)	Transport	(12.0)	Transport	(12.1)	Transport	(12.7)
2	Transport	(14.7)	Transport	(14.9)	Foodstuff	(15.0)	Other manufacturing	(9.1)	Other manufacturing	(8.0)	Other manufacturing	(8.2)
3	Warehousing	(11.0)	Warehousing	(10.4)	Warehousing	(11.1)	Foodstuff	(6.3)	Foodstuff	(7.1)	Foodstuff	(6.4)
4	Chemicals	(6.4)	Chemicals	(6.3)	Chemicals	(6.2)	Agriculture	(5.3)	Agriculture	(5.9)	Timber & wood products	(5.8)
5	Other manufacturing	(5.5)	Other manufacturing	(5.8)	Other manufacturing	(5.8)	Automobile & parts	(5.3)	Timber & wood products	(5.7)	Agriculture	(5.5)
6	Metal ware	(4.1)	Automobiles & parts	(3.8)	Metal ware	(4.2)	Construction	(5.2)	Construction	(5.0)	Metal ware	(5.4)
7	Pulp & paper	(3.8)	Metal ware	(3.8)	Pulp & paper	(3.9)	Timber & wood products	(5.0)	Automobiles & parts	(4.5)	Automobiles & parts	(4.7)
8	Electric machinery	(3.8)	Pulp & paper	(3.7)	Electric machinery	(3.8)	Metal ware	(5.0)	Metal ware	(4.5)	Construction	(4.5)
9	Automobiles & parts	(3.5)	Electric machinery	(3.4)	Automobile & parts	(3.8)	Transportation equipment	(4.7)	Warehousing	(4.2)	Service & communication	(4.4)
10	Transportation equipment	(3.3)	Department store & super market	(3.1)	Department store & super market	(3.4)	Warehousing	(4.1)	Transportation equipment	(4.2)	Transportation equipment	(4.3)
Total of 1 to 10	71.2		72.2		72.6		62.0		61.2		61.9	

(Data source: Japan Industrial Vehicles Association)

2. Development concept and Its aim

The basic concept underlying this development program was realizing “a thrust into the larger market of engine powered forklift trucks”. In order to achieve this objective, we undertook to overcome a long standing weak point of battery powered type lift trucks, i.e. insufficient power, by bringing it up to the level of the engine type, while simultaneously magnifying the merits of the battery powered type. In more concrete terms;

① To increase travel performance through the adoption of an AC travel motor
② To render the lift truck maintenance-free through the adoption of an AC travel motor
③ To decrease directional shock to the load while in travel or material handling modes through the adoption of an AC motor and PSVS
④ To work out a design that incorporates optimizing nine performance specifications geared to user needs.
⑤ To provide an assortment of batteries best suited to increasing the length of operating time
⑥ To ensure elaborate truck safety devices and a wide variety of attachments

3. The means for achieving the goals.

3. To increase travel performance through the adoption of an AC travel motor

In 2-wheel drive battery powered forklift trucks, the power train (**Fig. 6**) has a one-piece drive shaft structure (front wheel shaft). (See **Fig. 7**) For this travel motor, we adopted a 3-phase

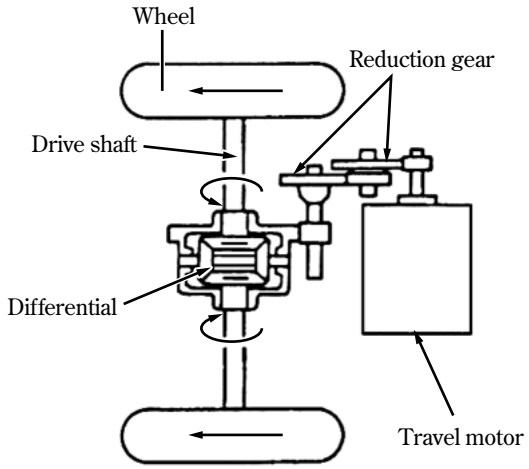


Fig. 6 Power train of battery powered forklift truck

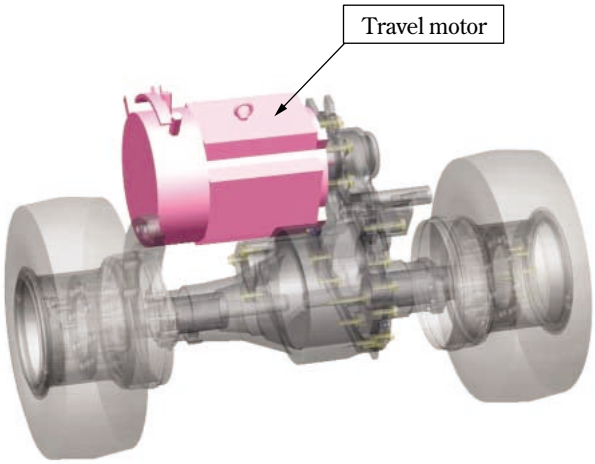


Fig. 7 Driveshaft of a battery powered forklift truck

AC induction motor (**Fig. 8**) that is controlled by an inverter. (See **Fig. 9**) As a result of these innovations, the travel speed has been enhanced by 10%, the gradability by 27% and the start-up acceleration by 15%. (See **Fig. 10**) Moreover, while incorporating a new AC travel motor, we also developed a new controller on our own. It not only has a forced air-cooling system to combat overheating, but also a function that measures the temperature of the travel motor itself and automatically regulates its output to prevent the motor from overheating.

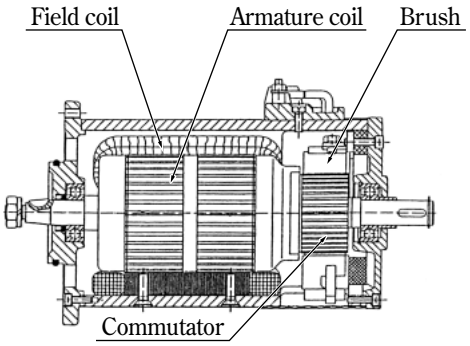
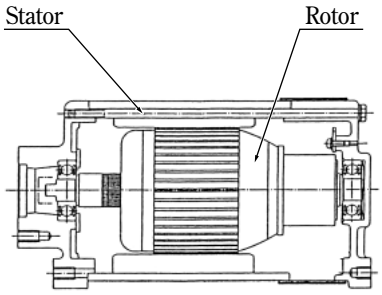
Item	DC	AC
1. Structure	DC Series Motor 	3-phase Induction Motor 
2. Characteristic	(1) Brush & commutator ⟶ Maintenance required (2) Complex structure and limit to high output (3) Maximum rotation speed —— Approx. 3500 rpm	(1) No wear parts ⟶ Maintenance-free, and thus high reliability (2) Simple structure and easy to generate high output (3) Maximum rotation speed —— Max. 5000 - 10000 rpm (in case of electric car)

Fig. 8 Structure of AC travel motor

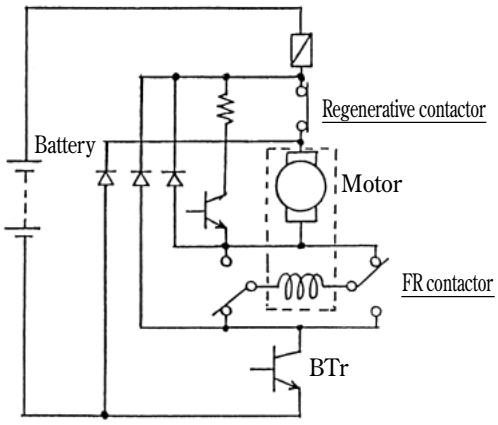
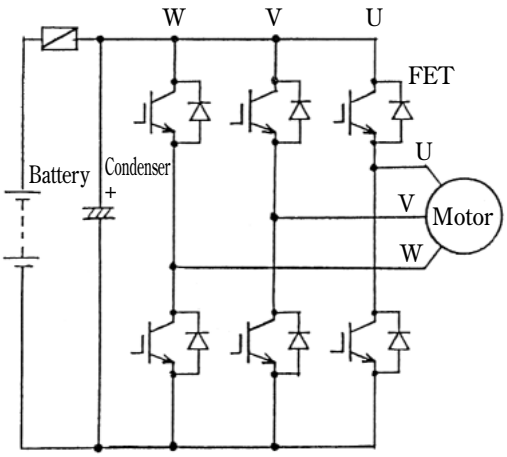
Item	DC	AC
1. Output circuit		
2. Control	Transistor chopper control	Inverter-controlled With cooling fan
3. Semiconductor in use	IGBT (1 pc.)	FET (parallel connection)
4. Modulation method	Rectangular wave PMW 400 Hz (audible frequency)	Sane wave PMW 10 kHz (non-audible frequency)
5. Wear parts	F/R contactor & regenerative contactor	Only main contactor (to be turned ON, when the starting key is turned ON)

Fig. 9 Control of AC travel motor

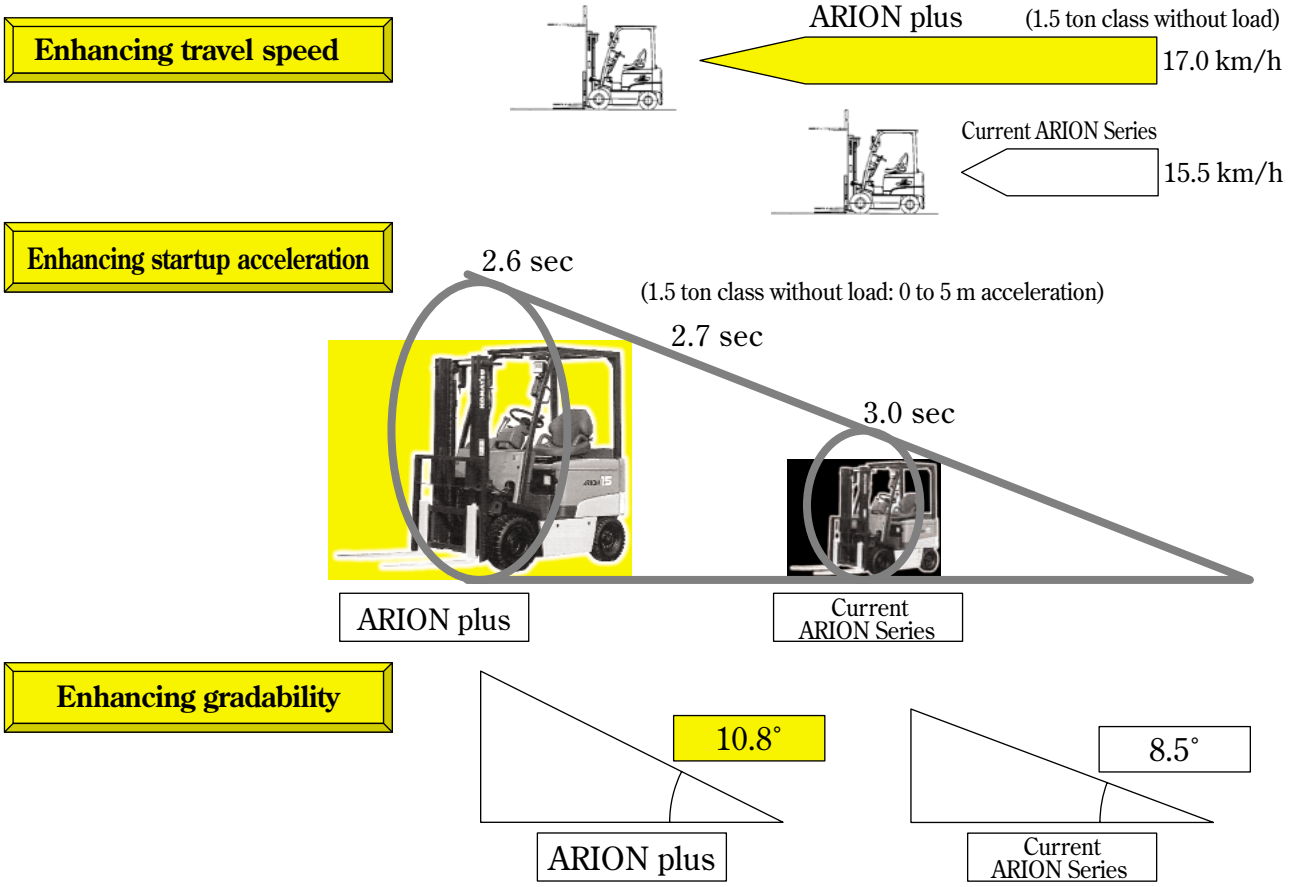


Fig. 10 Enhancement of travel performance

There are more improvements resulting from the adoption of an AC travel motor. One is a function termed "slope regenerative braking". It enables the truck to automatically select "crawling speed" when the operator releases the accelerator on a slope, thereby enabling the truck to safely descend the slope. This function may truly be said to have enhanced safety in driving as compared with the conventional DC travel motor, as the conventional one is of such structure that the brake does not work until the forward-reverse lever is moved in the direction opposite to that of the trucks travel. Another improvement is that the motor output no longer depends on the battery discharge rate. With the conventional DC travel motor, as operating time increases, the battery discharge rate rises while the motor output lowers, resulting in a lower overall working efficiency. With the AC travel motor, however, the motor output always remains constant, even though the battery discharging rate rises, thus not negatively impacting the overall working efficiency.

3.2 To render the lift truck maintenance-free through the adoption of an AC travel motor

As seen in **Fig. 8**, the AC travel motor we have decided to adopt this time has no brush, which has in turn removed brush maintenance (replacement), leading to the reduction of maintenance cost on the part of users. Another merit of the AC travel motor is that it does not need a normal-reverse rotation contactor as required with DC travel motors, thereby saving the contactor maintenance cost. Overall, this change has resulted in a considerable reduction in maintenance costs to the user.

3.3 To decrease directional shock to the load while in travel or material handling modes through the adoption of an AC motor and PSVS

It has already been mentioned that an AC travel motor does not need a normal-reverse rotation contactor. Without a contactor, a potential cause of abrupt directional changes, along with its associated noise of operation, are eliminated, making the new forklift more user-friendly. For control of the new truck's work equipment, we have adopted a unique PSVS (proportional solenoid valve system). In the conventional system, the work equipment control lever controls a direct acting type hydraulic valve. With the PSVS, the work equipment controller receives a signal from the control lever and operates a proportional solenoid valve. This mechanism promises more precise control of the work equipment plus shock-free start and stop of the forklift truck, which translates into fewer load spills. The last improvement associated with adoption of the PSVS is that lift cylinder hydraulic drift has been reduced by as much as 35% as compared with lift cylinder drift of conventional lift trucks. (See **Fig. 11**)

- Shock-free startup and stop prevent material spills
- Cylinder hydraulic drift and tilting amounts largely reduced (–35% compared with other Komatsu trucks)

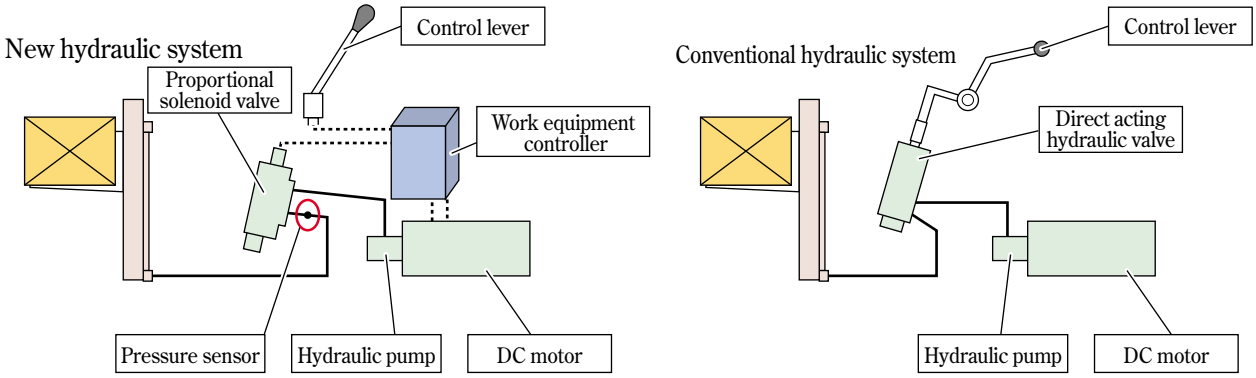


Fig. 11 PSVS (Proportional Solenoid Valve System)

3.4 The adoption of an AC travel motor enabled us to establish nine operating performance characteristics, as opposed to eight for conventional forklift trucks. They include:

- Characteristics an operator may set
  - ① Travel power
    The max. travel speed and acceleration performance can be set in eight stages.
  - ② Fork lift speed
    The mast lifting speed can be set in eight stages.
  - ③ Mast tilt speed
    The mast tilting speed can be set in eight stages.
- Characteristics a service mechanic may set
  - ④ Plugging regenerative characteristic
    The forward-reverse switchback distance can be set in 100 stages.
  - ⑤ Braking regenerative characteristic
    The electrical braking force can be set in 100 stages.
  - ⑥ Soft startup characteristic
    The startup acceleration characteristic can be selected from three patterns.
  - ⑦ Acceleration characteristic
    The travel speed can be selected from three patterns of the accelerator pedal step-on angle.
  - ⑧ Accelerator neutral characteristic
    The electrical braking force, which is activated only by releasing the accelerator pedal, can be set in 100 stages.
  - ⑨ Slope regenerative characteristic
    Use of the electrical brake, which is activated by releasing the accelerator pedal when climbing down a slope, can be set in ON and OFF.

Thus, we have provided users with a system that enables them to choose the combination of various characteristics that are best suited to their working requirements. (See **Table 3**)

Table 3 Sample of setting up performance characteristic

Sample of setting up	Outdoor work requiring high power	Work inside narrow warehouse
1. Travel power	8 7 6 5 4 3 2 1	8 7 6 5 4 3 2 1
2. Plugging regenerative characteristic	100 ····· 60 ····· 1	100 ····· 50 ····· 1
3. Brake regenerative characteristic	100 ····· 60 ····· 1	100 ····· 18 ··· 1
4. Soft startup characteristic	A B C	A B C
5. Acceleration characteristic	A B C	A B C
6. Accelerator pedal neutral regenerative characteristic	100 ····· 40 ····· 1	100 ····· 7 ··· 1
7. Fork lifting speed	8 7 6 5 4 3 2 1	8 7 6 5 4 3 2 1

* Do not attempt to imitate the examples shown above, because the given parameters might not be suitable to your actual working conditions.

* Except for travel power, fork lifting speed and mast tilting speed, ask your Komatsu Forklift distributor for proper set- up.

3.5 To provide an assortment of batteries best suited to operating time requirements.

In addition to the standard battery (for 1 to 3 ton class), a special battery for long operating times (for 1.5 to 2.5 ton class) is now available. The standard type allows up to 6-hours of continuous operation, while the special type allows a maximum of 12-hour continuous operation. Moreover, the standard type is available in three to four capacities, according to a truck class. Thanks to this wide variety, users are allowed to select the optimum battery that matches their job needs. (See **Table 4**)

Table 4 Major device and function

■ Major devices and their function

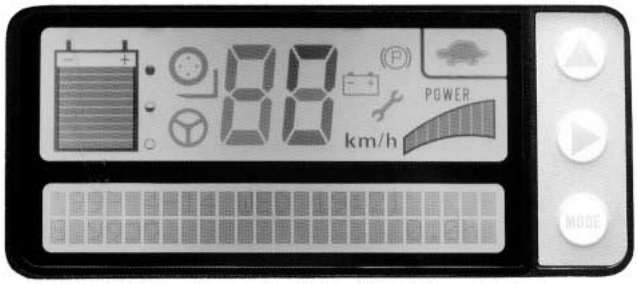
Legend
●: Standard ○: Optional △: Setup to be decided on each occasion of enquiry —: Not to be setup

No.	Items of Device & Function		Std. truck (EX type)							Small-sized special spec. truck (EXL type)						Long time operating truck (EXG type)			
			10EX	14EX	15EX	18EX	20EX	25EX	30EX	10EXL	14EXL	15EXL	18EXL	20EXL	25EXL	15EXG	18EXG	20EXG	25EXG
1	ICS (Intelligent computer control system)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2	PSVS (Proportional solenoid valve system)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3	EPS		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
4	Travel characteristic adjusting function	Travel power	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5		Soft startup characteristic *	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6		Acceleration characteristic *	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
7		Plugging regenerative characteristic *	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
8		Braking regenerative characteristic *	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
9		Acceleration pedal neutral regenerative characteristic *	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
10		Slope regenerative characteristic *	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
11	Work characteristic adjusting function	Fork lifting speed adjustment	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
12		Mast tilting speed adjustment	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
13	IMS (Intelligent monitoring system)	Speed meter	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
14		Travel speed control indicator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
15		Display of service meter	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
16		Odometer	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
17		Display of calendar	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
18		Travel power indicator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
19		Battery electrolyte level indicator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
20		Battery capacity indicator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
21		Parking brake indicator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
22		Failure indicator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
23	Operating device	Tilt & telescopic type steering	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
24		Auto-return type turn signal lever	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
25		Left side forward-reverse control lever	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
26	Safety aiding device	Travel & material handling lever neutral safety function	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
27		Anti-roll back function	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
28		Emergency power shut-off button	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
29		Parking brake with lock	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
30		Excessive speed alarm	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
31		Backup alarming buzzer	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
32		Forward-reverse alarm chime	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
33		Rear view mirror (right)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
34		Rear view mirror (left)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
35		Travel speed limit	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
36		Rear lamp	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
37		Revolving flashing lamp (yellow / red / blue)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
38		Fire extinguisher (installed on head guard)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
39	Work aiding device	Fork position indicator	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
40		Auto rocking stopper (with auto at-level stopper)	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△
41		Load weight meter	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△
42	Cab and exterior parts	HSS sheet (suspension type)	●	●	●	●	●	●	●	—	—	—	—	—	—	●	●	●	●
43		HSS sheet (non-suspension type)	—	—	—	—	—	—	—	●	●	●	●	●	●	—	—	—	—
44		Steel cabin	△	△	△	△	△	△	△	—	—	—	—	—	—	△	△	△	△
45		Resin-made head guard cover	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
46		Side window with windshield wiper and washer	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
47	Other	Floor mat	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
48		Side pocket	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
49		Memo pad with board	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
50	Battery charging and maintenance	Battery with water supplier	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
51		Microcomputer charger	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
52		Quick charger (fixed type)	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△
53	Battery	Voltage	48V						72V	48V						48V			
54		330Ah/5HR	●	●	—	—	—	—	—	●	●	—	—	—	—	—	—	—	—
55		400Ah/5HR	○	○	●	●	—	—	—	—	—	●	●	—	—	—	—	—	—
56		450Ah/5HR	—	—	—	—	●	—	●	—	—	—	—	●	—	—	—	—	—
57		485Ah/5HR	○	○	○	○	—	—	—	○	○	○	○	—	—	—	—	—	—
58		545Ah/5HR	○	○	○	○	—	—	○	○	○	○	○	—	—	—	—	—	—
59		565Ah/5HR	—	—	—	—	○	●	—	—	—	—	—	○	●	—	—	—	—
60		600Ah/5HR	—	—	—	—	○	○	—	—	—	—	—	○	○	—	—	—	—
61		700Ah/5HR	—	—	—	—	○	○	—	—	—	—	—	○	○	●	●	—	—
62		725Ah/5HR	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—
63		935Ah/5HR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	●	●
64		1080Ah/5HR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	○

*: Ask your Komatsu Forklift distributor for proper setup.

3.6 To ensure elaborate truck safety devices and a wide variety of attachments

With the new model, additional safety devices have been added. They include an emergency power shut-off button and a neutral safety function. Additionally, a newly adopted intelligent monitoring system (IMS) displays diver's information such as remaining battery capacity, travel speed, etc. Travel power and work equipment speed can also be set using the IMS. (See **Fig. 12**)



Intelligent Monitoring System
- Display of battery capacity remaining
- Display of travel speed
- Display of service meter reading
- Display of power
- Display of travel speed and max. allowable travel speed
- Display of battery electrolyte abnormality
- Display of current time
- Display of parking brake
- Display of various warnings and abnormalities

Performance Set-up
- Travel power
- Plugging regenerative characteristic
- Brake regenerative characteristic
- Soft startup characteristic
- Acceleration characteristic
- Acceleration characteristic
- Accelerator pedal neutral characteristic
- Slope regenerative characteristic
- Fork lifting speed adjustment
- Mast tilting speed adjustment

Fig. 12 IMS display

4. Environmental consideration

A battery powered forklift is in itself an environmentally friendly product. In this chapter, though, we will introduce other company-wide environmental protection activities at Komatsu Forklift.

For example, a lift truck counterweight is a cast-iron product used with forklift trucks in general. With the conventional manufacturing method, the rough surface of a cast counterweight is first covered with putty powder, then ground to make the surface even and smooth and finally coated with paint. This lengthy preparation process is required to enhance its ease of painting for a better external appearance. However, the grinding work produces significant amounts of airborne metal dust and powder. Although the counterweight itself can be recycled when a lift truck is removed from service and scrapped, disposal of the hazardous putty powder presents an environmental concern.

In July, 2002, to mark the introduction of its new engine powered forklift models, Komatsu Forklift switched from its conventional counterweight painting method to the texture painting method for both small-sized engine powered and battery powered forklift trucks. The texture painting method is a painting method that creates a painted surface with irregularities similar in appearance to a satin finished surface. Although painted directly on the unground cast surface, the finish appears no different from that of the conventional painting method. Through the adoption of the texture painting method, we could almost completely eliminate grinding work using putty powder.

It should be noted that counterweights for some of the engine powered forklift trucks have grooved separation joints molded into their interior surfaces so that a power press can easily split the counterweight into pieces when it is recycled.

5. Conclusion

New models of the ARION Plus Series have been selling well ever since their introduction into world markets, a fact that proves the soundness of our original development concept. The introduction of an AC travel motor helped battery powered forklift trucks catch up with the engine powered types in terms of travel performance. But the problem of shorter continuous operating times still persists. In order to narrow this disparity, the next objective will be to shorten both battery charging time, through a so-called quick charging method, and battery replacement time.

Another shortcoming of battery powered type forklifts, as compared with the engine types, lies in their much higher initial procurement cost, the price being so high that the difference creates a stumbling block to the sales of new trucks. In order to close the cost gap with the engine type, manufacturing cost cutting for the major components will be required. It is our resolve to overcome these problems in the future, thereby contributing to better performance of Komatsu Forklift.

Introduction of the writers

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[A few words from the writers]

The battery powered forklift truck has a long history. Nevertheless, it seems to be lagging behind automobiles with respect to technical advancement, as auto manufacturers have introduced hybrid and fuel cell powered vehicles in rapid succession. More than ever, we will have to concentrate on creating and introducing new technology in this field of industry.