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Un-exploited available potential for higher train speed

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UNEXPLOITED AVAILABLE POTENTIAL FOR HIGHER TRAIN SPEEDS

BY
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ABSTRACT

True to innate human instinct of fostering mutual socio-economic contacts, the Rilways of the advanced countries have since embarked on phenomenal high speeds of the order of 250 Kmh and are continuously striving to raise these further.

The Pakistan Railways also planned, as far back as in fifties, to go in for speeds of 120 Kmh in case of Passenger/Express trains and of 70 Kmh for freight trains, so as not to be retrograded to virtual extinction. But despite strengthening of track and installing modern signalling on main line between Lahore-Karachi and import of high tractive power locomtives, the achievement of that humbler target remained a far cry till recently. The trains at 120 Kmh speed could not be stopped within stipulated safe distances with conventional vacuum braking sytem. The imported air pressure brake equipment on passenger/express trains, could not meet the requirements for that speed in its original form. Re-location of Signalling system to cater for additional distances reqired for stopping trains at higher speeds demanded huge resources. Equipping even selected services with air pressure brakes entailed exhorbitant finances in foreign exchange.

Replacement of four-wheeled freight wagons by bogie stock, condemning former on the basis of their incapability to run safely at higher speeds, was yet another constraint, as 96% of the freight wagons were of that description.

Under such conditions, the author was entrusted to undertake research, evolve modifications indigenously and conduct field trials in order to see whether it was possible to achieve higher speeds without reduction in the trailing loads.

Thanks to the patronage of the higher heirarchy and dedicated and zealous assistance rendered by his team, the author has finally succeeded in modifying the existing vacuum brake system in such a manner that both passenger/express and freight trains can be braked and stopped within safe distances, not only at the stipulated higher speeds of the order of 120 Kmh and 70 Kmh respectively but at even ever greater speeds. The suspension of the four wheelers has also been modified. The field trials of freight trains have successfully been conducted at 90 Kmh instead of 70 Kmh planned originally. The trailing loads, instead of being curtailed, were rather enhanced by 5% over those originally in vogue for the speeds of 55 Kmh and planned for 70 Kmh thereafter. The research activity which has involved virtually nothing in financial terms has also obviated spending of millions worth of foreign exchange which would otherwise have been needed for replacement of four wheelers by bogie stock and for import of air pressure brakes to brake trains at higher speeds.

Pakistan incidentally is the first country in the world to cross the conventioanl speed barrier with indigenous research effort in the field of braking mechanism and we can be reightly proud of this achievement.

INTRODUCTION

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Never start a thing that you cannot stop is an old maxim which is still true to its words. And start we must because it is life. Conversely, inertia or stagnation is deacy or death which in turn is end and end we loathe. All the same, start unbriddled or uncontrolled becomes erratic, goes astray and leads to chaos and ultimate purposeless end which is no less abhorring. The analogy, therefore, is that we do start but with complete sway and with absolute control to stop at will. In keeping with this analogy, the civilization has progressed and prospered. In the very beginning, the only start, the movement or the transport was by means of canoes or the rafters. These were slow to sail and could be stopped at that ease. The habitations grew and life throbbed at the river banks alone. The inbred human instinct to shun inertia and to move faster did not remain content with it and evolved wheel. Cattle driven carts and coaches though a little faster, yet easy to stop, opened new inland vistas. New dwellings mushroomed and civilization took another stride. The quest for still faster contacts ushered in an era of mechanization. The dumb driven cattle, the source of power for moving transport, gave way to mechanical propulsion. There came the road carriers with metalled roads and almost simultaneously came the railways with their own rail tracks. The stopping or braking mechanism strategy, as already mentioned had to keep abreast of the motion, and as such the hand operated stoppers were augmented with other kinds viz mechanical, hydraulic or air pressure ones on road vehicles and automatic vacuum or air pressure brakes etc. on the railways.

HISTORICAL BACKGROUND

The present Pakistan Railways was originally a part of the North Western Railway of the pre-independence days. The traction was through steam locomotives and the rolling stock was capable of running upto the speed of 60 Mph (95 Kmh) in case of passenger/express trains and 45 Mph (70 Kmh) in case of freight wagons. The goods trains, however, were run upto a maximum speed of 30 Mph (55 Kmh) on account of braking limitations.

Serious concern was shown in mid fifties for increasing the speed of passenger/express as well as goods trains on Pakistan Railways. Development plans were, therefore, prepared to achieve target speeds of 120 Kmh in case of passenger/express trains and 70 Kmh in case of freight trains. Improvements were necessary in track structure. its layout and geometry, signalling system, tractive power and the rolling stock. While efforts were being made to improve the other infrastructure, a Senior Mechanical Officer, as far back as in 1957, was assigned the task of conducting field trials to suggest ways and means for improvement of the rolling stock with a view to increasing the conventional speeds. Series of trials were conducted but only a marginal speed increase of 5 Mph i.e. 8 Kmh could be achieved.

Serious attempt was once again made when a special post of deputy Chief Mechanical Engineer was created in early 1975 for in-depth study for suggesting ways and means of improvements in the train speeds. World Bank Team and Consultants like Sofrerail of France had suggested numerous remedial measures comprising empty load device, slack adjusters, direct admission valve, composite brake shoes and air brake equipments for improvement of the braking system. All these equipments had to be imported at the expense of hard earned foreign exchange. The results of the trials of these equipments were unfortunately not encouraging by and large. Compressed air brake was, however, one out of these equipments, which proved to be effective for higher speeds. But on account of its high imported price as already stated, it could barely be adopted on a few mail/express trains. This too when tried for speeds of 120 Khm proved inadequate in its original form.

The state of affairs remained static without any further break through till April, 1986 when the author was assigned to study the subject, evolve modifications and conduct field trials to see if the conventional speeds could be raised by indigenous research.

IMPROVEMENT NEEDED IN THE ROLLING STOCK.

The paper deals with the improvement of suspension arrangements and the braking of the rolling stock needed for higher speeds. The other components for high speed namely tractive power, track and signalling etc., not being within the purview of this paper, are left-out. Before dwelling upon the improvements made and tried for higher speeds, it would be pertinent to have a birds eye view on the above mentioned basic requirements of the rolling stock.

(a) Suspension

Apart from the structural stength of the rolling stock viz passenger carriages and the freight wagons, it is an obligatory requirement of the railway vehicles that wheel rail contact is not lost to the extent that the wheel flange, the only steering mechanism, leaves the rail. The wheel in that eventuality goes off the rail and results into unfortunate phenomena of derailment, bringing in its wake, grave dis-aster. The conventional suspension of a four wheeled wagon is of such a type that a vehicle is unsafe to run beyond a speed of 70 Kmh, on account of the undampened vertical oscillation which causes the flange of the wheel to lose contact with rail.

(b) Brakes.

The next and the most important requirement of the rolling stock for higher speeds is the brakes. Pakistan Railways could not run the trains even to the designed speed of the vehicles because the trains could not be stopped within a safe braking distance if the speeds were to be increased beyond 55 Kmh in case of freight trains.

It would not be out of place to mention here that safe braking distances are fixed by every Railway, depending upon the signal spacing and other operating conditions. On Pakistan Railways the safe braking distance is fixed as 1200 metres i.e. 3/4th of a mile.

IMPROVEMENTS MADE IN SUSPENSION

The area necessitating the improvements of a four wheeled wagon is indicated in dotted line at Fig-1. The element of modification is as shown at Fig-2. This is basically an adoption of the design of the UIC standards. We can proudly claim that this has been further improved to eliminate one serious draw back of causing the derailment of a wagon while running at higher speeds in the event of unfortunate spring fracture. This short-coming has been overcome by providing a safety stopper as is indicated at Fig-3. This is a novel addition evolved through research, without which even the foreign design could not cater for the safety of the train.

IMPROVEMENT NEEDED IN BRAKES.

The brake system on Pakistan Railways is what is called 'Automatic Vacuum Brake System'. Vacuum is maintained in the system while the train is running and is destroyed to the extent required for brake application. Metallic brake blocks rub on the rotating surface of the wheel, developing frictional force to consume the momentum of the moving train through a mechanism of pull and push rods and floating levers actuated by the piston thrust. (See Fig-4). Compressed air brake is not different to the vacuum brake system in its nature. The brake force in that case is developed through the compressed air but ultimately it is the frictional force which stops the train and is developed by rubbing the brake block on the wheel surface in a similar way as is done by the vacuum system. The cieling in both the cases is the co-efficient of friction between the rubbing material and wheel surface. The notion as to why compressed air brake be treated superior to the vacuum brake system if the two things are identical in nature so far as braking is concerned, as explained above, prompted the research and field trials.

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BRAKE FORCE

The braking force is the multiple of pressure exerted on the brake blocks and the co-efficient of friction of the rubbing material on the wheel surface. Cast iron brake blocks, the rubbing material, are manufactured by the Pakistan Railways in its own foundries at Moghalpura. Taking cast iron material as invariable factor, increase of the brake force was the other alternative to obtain higher frictional force. Whether it is vacuum cylinder or the compressed air brake cylinder, the amount of the force generated at source is transmitted to the brake block through a set of pull/push rods and the floating levers as explained earlier. We had two options here, namely either to increase the force at source or re-design the brake leverage to provide the desired amount of force at the brake blocks.

Different combinations were, therefore, tried. Pakistan Railways is using three different sizes of the vacuum cylinders for broad gauge rolling stock. These are of 18", 21" & 24" diameters. Different lever ratios were also tried. Merits and demerits were experienced in each of the combinations. Through series of trials, it was established that provision of two 18" vacuum cylinders on a four wheeled wagon and four 18" vacuum cylinders on a bogie wagon, with a transmission leverage ratio of 1:10 gave the best combination for obtaining the optimum brake force on the brake blocks. The arrangement for additional brake force in four wheeler and the bogie wagons, as shown in Figs. 5 and 6 respectively were adopted.

It would be appreciated that making any amount of force available on the brake block is no longer an impossibility and, therefore, theoretically has no end. This frictional force, however, should not be greater than the adhesive force between the wheel and the rail. Otherwise we will experience the wheel skidding.

The other important feature of the frictional brake phenomena is the time factor i.e. the time required to cause a complete brake application on the trailing load when the driver manipulates the brake applicatin handle. It may be clarified here that some time is spent in causing destruction of the vacuum throughout the train length in vacuum brake system, or for propagation of the air in the compressed air brake system, when brake application is initiated from the locomotive by the driver. vacuum destruction is at the speed of about 100 metres per second whereas the compressed air propagates at the speed of 300 metres per second i.e. the latter is three time faster than the former. For this reason, complete brake applicatin in a vacuum braked train of about 700 metres length, consisting of about 72 wagons which is the maximum length of ran on Pakistan Railways, is caused in about 90 seconds where as similar action in air brake is completed in about 30 seconds. Air brake, therefore, in this respect, claims superiority over the vacuum brake because the free travel distance of the train after brake manipulation in case of air brake system is far lesser as compared to the one in the vacuum brake system.

This aspect of the brake application had drawn the attention of the different railways and the brake manufacturers. The vacuum brake system could become as good as the air brake system or even superior to it, depending upon the extent to which propagation time could be reduced. To achieve these ends, direct admission valves of different designs have been evolved by the various manufacturers. These are meant to open the vacuum train pipe at different places in the train length to the atmosphere for quick destruction of the vacuum and thereby reducing the application time or the response time. Pakistan Railways also imported such valves and installed them on the wagons alongwith other improvements like brake regulators, empty load devices and composite brake shoes etc.

The desired results unfortunately could not however be achieved in spite of spending hard earned foreign exchange, that could be available.

the Guard Van Valve which is an ordinary indigenous equipement in the brake vans of the guards,

was studied in detail and different modifications were tried. It was intended to exploit the automatic action of the guard van valve as a consequence of emergency application of brakes from the locomotive which causes the air to enter simultaneously from it and helps brake the train by minimizing the free travel distance. As a result of sustained and dedicated efforts on the part of the members of the trial team, an un-imaginable simple modification to the guard van valve had been finally settled as shown at Fig-7. A small reservoir has been attached with the top of the guard van valve. The size of the reservoir was determined after a series of trials so as to offer the necessary promptness of brake application from there unnecessary large reservoir would conversly have created troubles. The guard handle has also been removed and a small cock provided in lieu to prevent the possibility of undesired manual application of vacuum brake from there.

Modification of the automatic guard van valve in the brake van has opened a new field. Control on brake application time has completely been mastered. The brake application time as such can be minimised proportionately with the use of this valve, christened as booster valve. With the vacuum brake power as now provided on the train, only one modified guard van valve will suffice for controlling a full length of train running at 70 Kmh. One wagon fitted with this booster valve will be required to be marshalled in the centre of the train if the train is to be run at 80 Kmh. Every 12th to 15th vehicle must carry this booster valve if the train speed is intended to be of the order of 90 Kmh. The number of wagons with booster valves will be determined for speeds beyond 90 Kmh. The installation of the booster valve on the wagon is shown in Fig. 8.

The improvements in braking system whether on freight or passenger train, involving huge foreign exchange components suggested by the World Bank and the foreign consultants are altogether uncalled for and superfluous in the face of indigenous modifications of brake system that have been duly proved by trial runs and have rather been introduced on couple of express goods trains. The empty load device which has been purchased by the Pakistan Railways on the recommendation of the foreign experts is no longer required. Slack adjuster, yet another equipment, which was purchased by the Pakistan Railways on the recommendations of the foreign advice for stipulated improvement in brakes too has proved otherwise. This is simply a labour saving device as it takes up the brake block wear automatically and can hardly be attributed towards improvement of the brake power.

CONCLUSION

As a result of indigenous research proven through field trials, a mechanism in suspension as well as in the vacuum brake system has been evolved which has enabled the Pakistan Railways to cross the conventional speed barriers. A train consisting of freight wagons with improved fittings as metioned in the paper has been successfully run on the Pakistan Railways at higher speed of 90 Kmh. Colossal expenditure for replacement of four wheeled wagons with bogie stock otherwise necessary for running trains at higher speeds has happily been avoided.

With the newly evolved booster valve fitted on passenger coaches, express/passenger trains can be braked within safe distances at virtually any speeds. The innovation which has been brought about by purely indigenous research has not only offset expenditure of billions of rupees worth foreign exchange but has also opened new avenues through higher speeds and comfortable riding. And proudly Pakistan can claim to be a stalwart in this field.

ACKNOWLEDGEMENTS

I owe my profound gratitude to Engr. Main Ghiasuddin, General Manager Pakistan Railways whose lectures, at various places and times advocating need for research oriented developments,kindled in me

the inspiration to break away from the decadent groove of conventional complacency which enabled me to achieve the proud results outlined in the paper. I am further indebted to him for his benign patronage in arrangement of field trials, which I am certain, could not have otherwise been possible.

I also remain obliged to the relentless assistance and co-operation rendered by my team members in general and M/S. Abdul Khalique Carriage and Wagon Inspector Railway Headquarters Office and Abdul Aziz fitter goods sick line, Lahore Division in particular. Their sense of dedication and purpose of sincerity made the task easy and within early reach.

FIG. 1

Four Wheeler

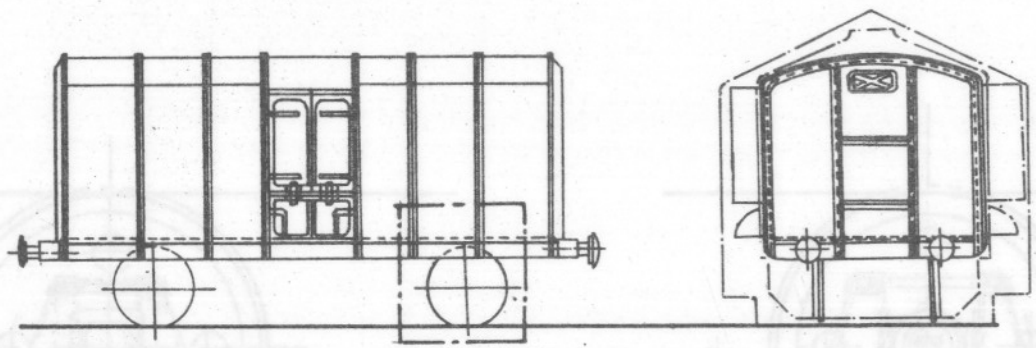

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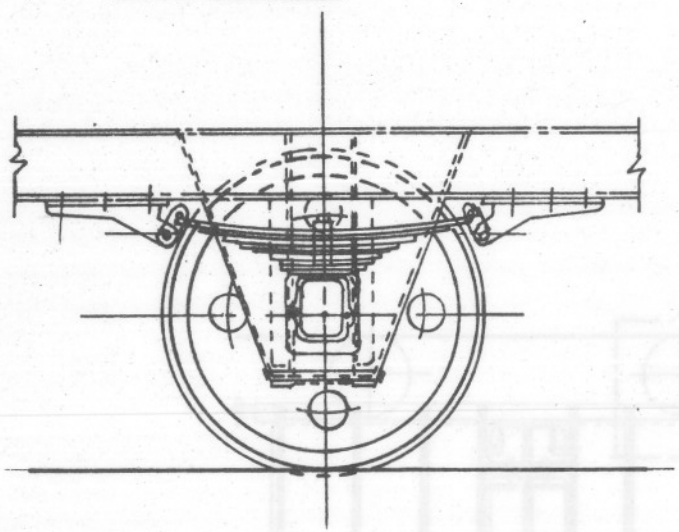
FIG: 2

Single Suspension
Plain Bearing



Double link Suspension
Roller Bearing

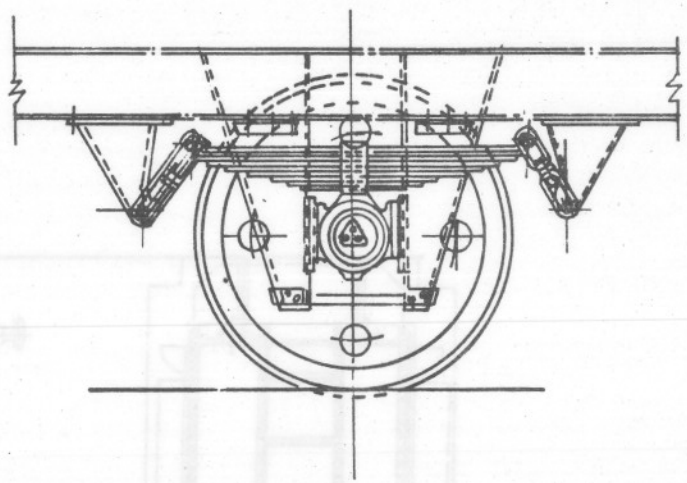


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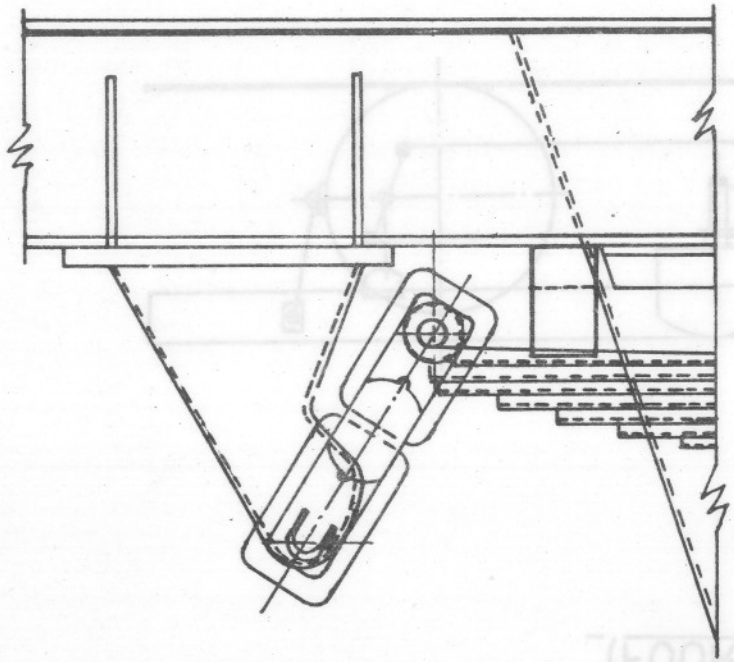
FIG: 3

Double Link Suspension With Roller Bearing

Detail of stopper



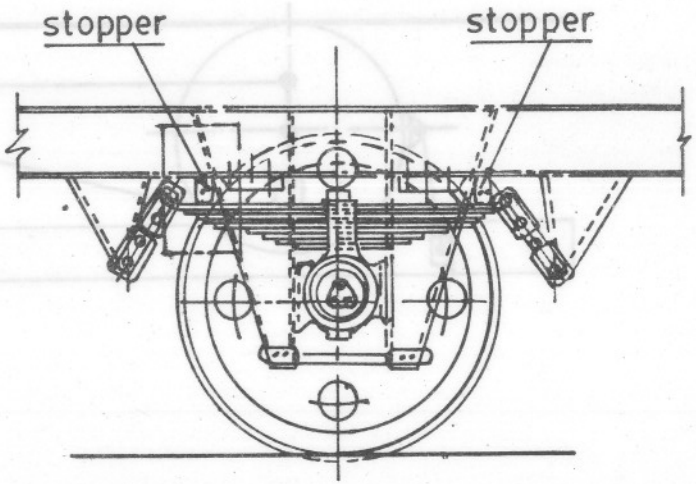


FIG. 4

BRAKE ARRANGEMENT
(FOUR WHEELER)

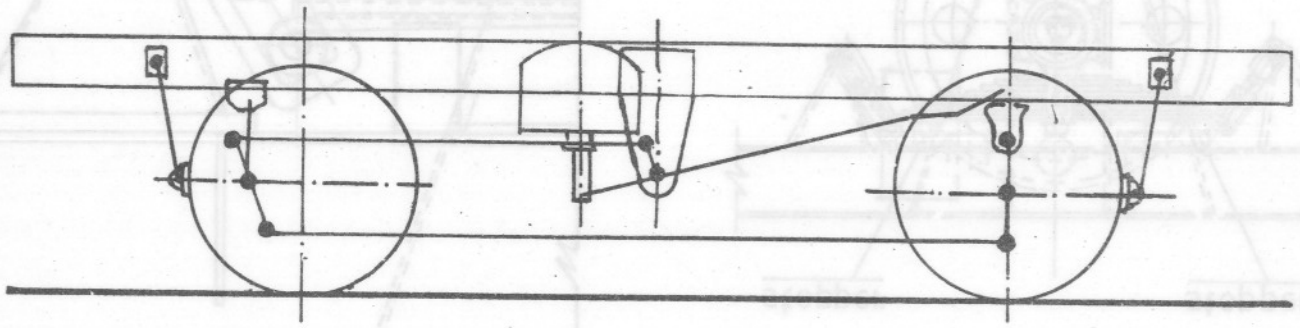


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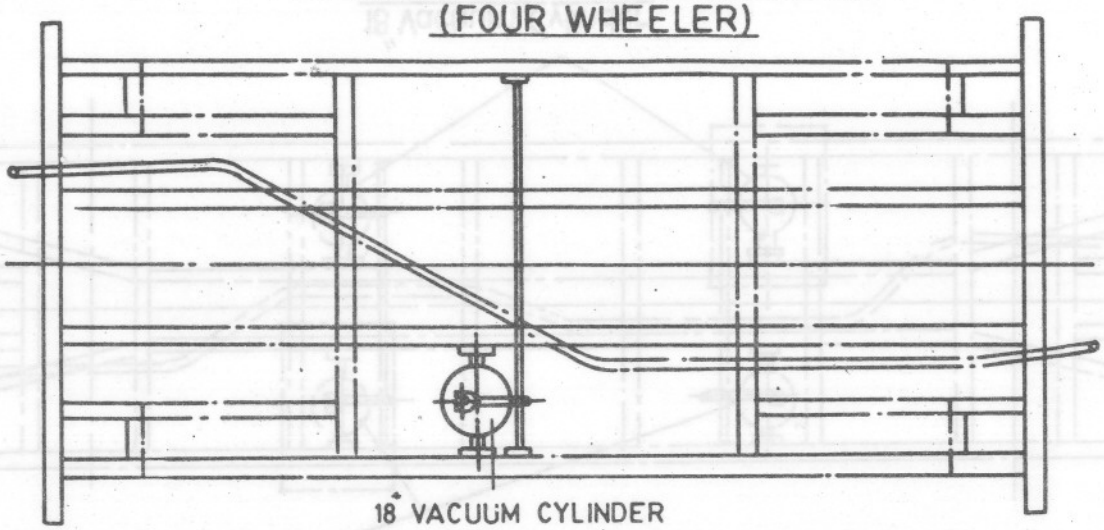
FIG: 5

EXISTING BRAKE ARRANGEMENT (FOUR WHEELER)



MODIFIED BRAKE ARRANGEMENT

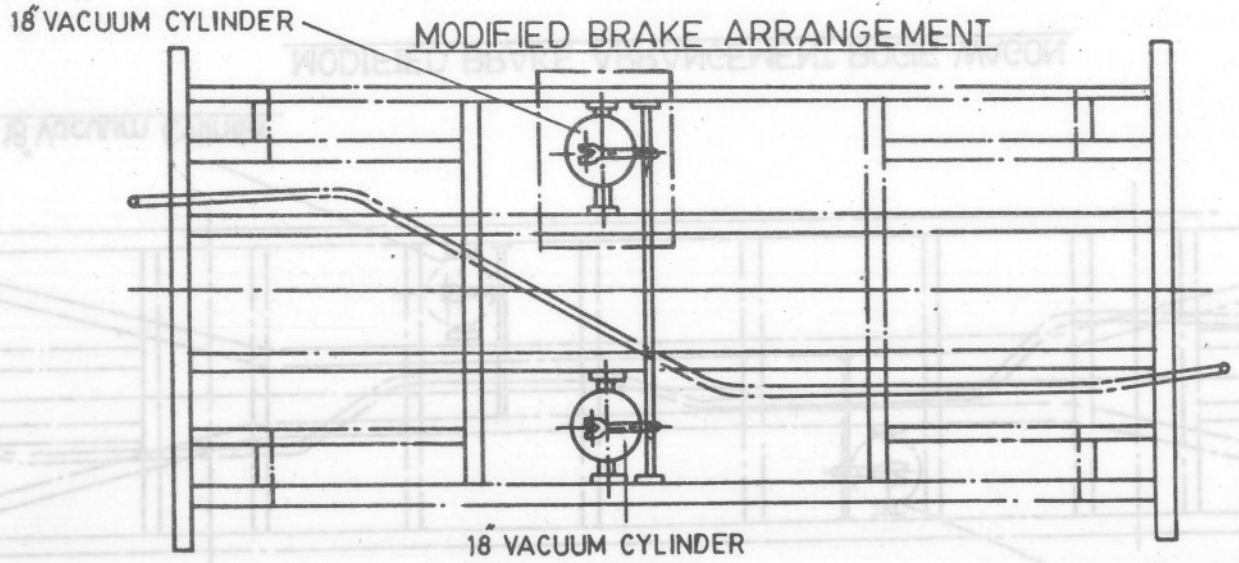


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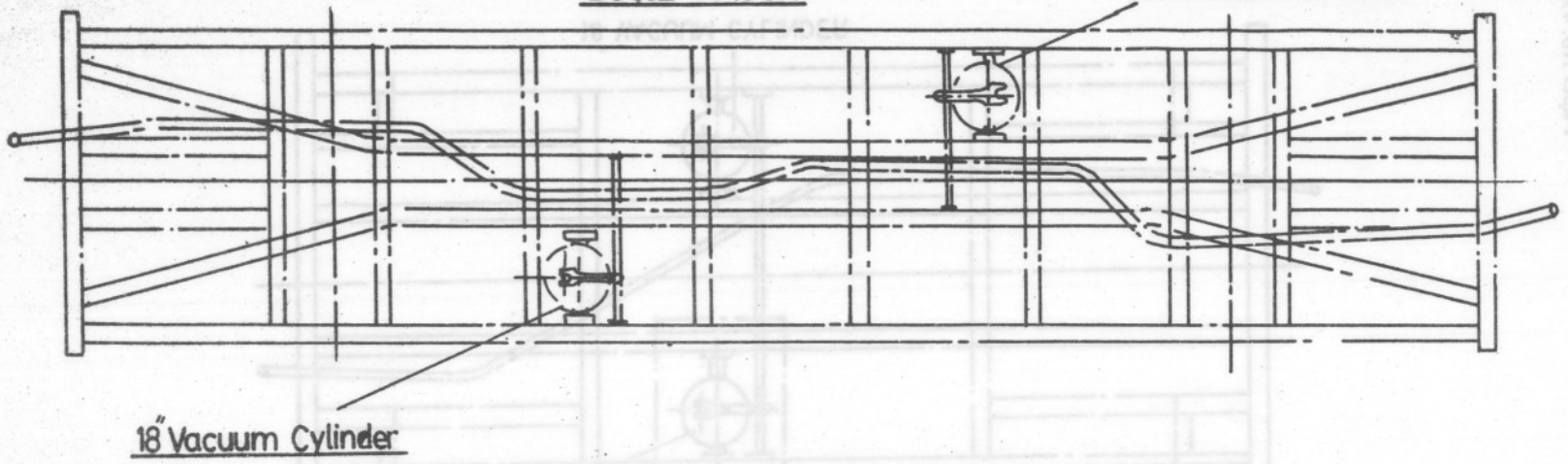
FIG: 6

EXISTING BRAKE ARRANGEMENT BOGIE WAGON



MODIFIED BRAKE ARRANGEMENT BOGIE WAGON

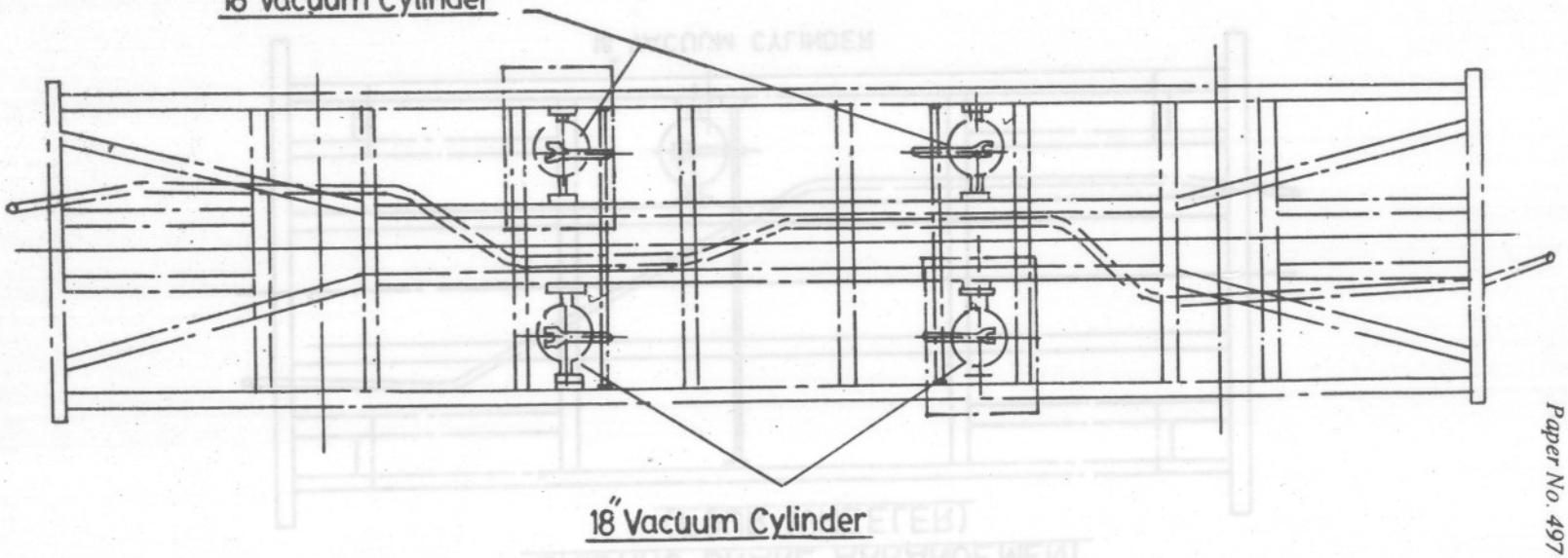
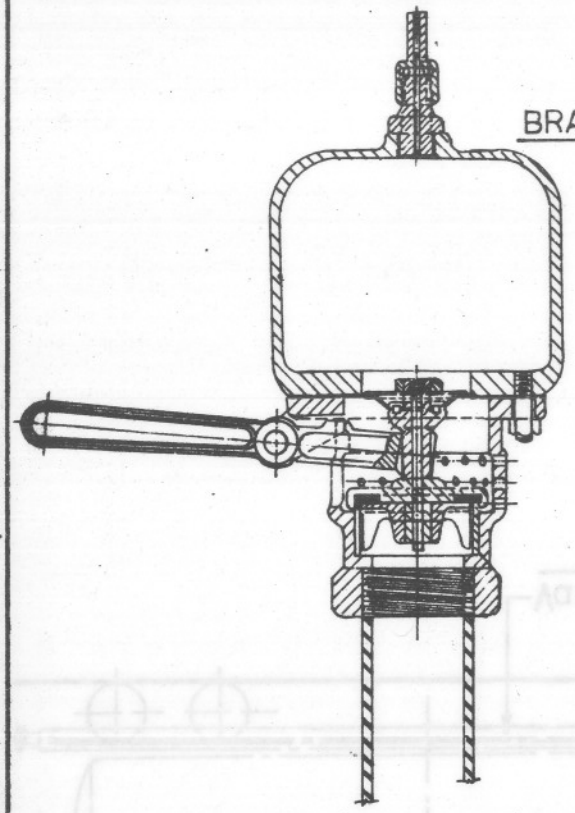


FIG: 7

EXISTING
BRAKE VAN VALVE



MODIFIED BRAKE VAN VALVE
WITH VACUUM CHAMBER

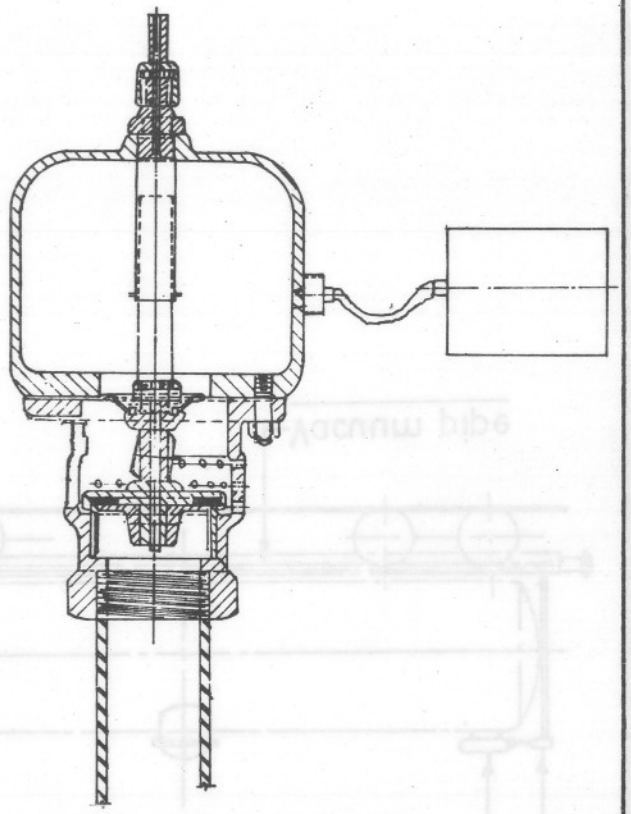


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FIG: 8

Tank Wagon With Booster