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Logging Truck Brakes

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A Thesis

Presented to the Faculty

of the

School of Forestry

Oregon State College

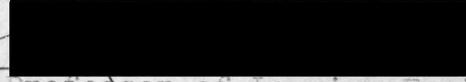
In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

May 1942

Approved: 


Professor of Logging Engineering

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CHAPTER I

Introduction

Up to the last few years the brake problem had not gained the importance that it is now gaining and will continue to gain in the future. As the timber is getting cut off the better shows, it is necessary to go farther back and into the rougher ground to get timber. This fact combined with the tendency toward the larger trucks which means larger loads, add up to a more serious braking problem. The braking problem includes the stopping of load trucks and the maintenance of the truck brakes.

The purpose of a brake on a logging truck is to stop a load and hold it under control. Theoretically this is the conversion of the energy of motion into heat energy and then the dissipation of this heat energy. The process of braking is exactly the opposite of that of an internal combustion engine. In the engine heat energy from the fuel is being converted into motion while in braking it is the opposite. The quickest stop can be made by applying sufficient brake pressure to almost, but not quite, sliding wheels. This requires high brake pressure for high velocities but a gradual lessening in brake pressure (to avoid skidding) as the velocity lessens.

The braking in most brake systems is obtained by friction between a brake shoe and a drum which converts the

energy of motion to heat energy. The coefficient of friction of the brake lining determines the amount of pressure necessary to obtain the maximum braking effect. The braking effect is materially reduced when brakes become heated. This reduction in braking effect is caused by the loss of the ability of the friction surfaces to resist abrasion due to the high temperature. The dissipation of this heat in most brakes is done by conduction, convection, and radiation. By conduction the heat is dissipated from the friction surfaces to brake drums, brake shoes, backing plates, hubs, wheels and axle housings, etc. All of these heavy metal parts act as heat reservoirs in this heat dissipation. By convection the heat is dissipated by the air sweeping past brake drums, shoes etc. By radiation the heat is dissipated from drums, shoes, etc. The capacity of brakes to absorb energy is very definitely limited by the rate at which a given brake can dissipate heat.

Another theoretical consideration to be noted is that when a motor vehicle is in motion, the effective center of gravity moves toward the rear axle and an important part of the load is transferred on the rear wheels. When rear wheel brakes are applied, the effective center of gravity moves well forward, increasing the load on the front wheels. This increases effect on the front wheels and reduces effect on the rear. Front wheel brakes are three times as effective as rear.

CHAPTER II

Types of Brakes

When speaking of a brake it is understood to mean a brake mechanism, but there is a way to brake a truck without the use of a braking mechanism. That is by the use of the motor. Under this heading of types of brakes the following will be considered: the motor as a brake and the braking mechanisms which include mechanical, hydraulic, vacuum boosters, air systems, emergency, and dynamic.

Motor as Brake

In the early days before the development of adequate brakes the engine was used in "compression" to act as a brake and help hold the vehicle under control. This method of braking is still used today on operations such as logging where the brakes are being badly overloaded.

There are two factors that operate, when an engine is running in "compression," that bring about the retarding effect. These two factors are (1) the engine acts as a vacuum pump in exhausting air from the manifold, (2) the losses in the engine itself due to the mechanical inefficiency. It takes approximately 20 horsepower to drive a 100 H.P. engine at its rated speed when it is operating with the throttle closed.

The use of the engine in "compression" has several advantages. This method of braking can be used on long grades

because the engine can absorb energy for long periods of time. A friction brake used on a similar condition would heat up and start to slacken or even fail due to the continued application. By the use of the motor the friction brakes are saved considerably.

The mechanical losses in the engine increase as the engine speed increases. That is the reason why the engines are run at such high speeds. The higher the speed the more the retarding effect. This high speed in "compression" is destructive to engines due to the high inertial forces. An engine running in "compression" can not be controlled by a governor, therefore a truck should have an adequate braking system in order to keep from wrecking the engine.

Although the diesel engine does not have the vacuum effect as the gasoline engine, it has about the same mechanical efficiency due to the longer pistons and larger bearing surfaces. The diesel engine has been operated just as successfully as the gasoline in "compression", but the overspeeding of a diesel is more destructive because of the higher inertia forces caused from the heavier reciprocating parts.

Mechanical Brake

The mechanical brake system is nothing more than a system of levers that transmit the pressure applied on the foot pedal to the brake shoe expanding cam. Through this system it is possible to multiply the force exerted on the foot pedal from 60 to 150 times. This is due to the small distance

the brake shoe must travel as compared to the distance the foot pedal moves.

This type of brake system work fairly satisfactory for the lighter loads and slower speeds as were used in the past. On this older type vehicle the two wheeled braking system was used. With the increase in size of loads and faster speeds, a more powerful brake was needed. Then the putting of brakes on the front wheels introduced complications that practically eliminated this type of brake. This type of brake, as far as logging trucks goes, has been eliminated and better balanced systems have taken its place.

Hydraulic Brake

The hydraulic brake system is made up of one master cylinder and a wheel cylinder on each wheel. When force is exerted on the brake pedal it is transformed into hydraulic pressure in the master cylinder. This hydraulic pressure is transmitted through a system of tubing to the wheel cylinders. These wheel cylinders then transform this hydraulic pressure into mechanical motion which expands the brake shoe. The master cylinder is connected directly to a supply in such a way that the liquid in the hydraulic system is always the proper amount. The wheel cylinders cylinders may have either one or two opposed pistons. In the double piston cylinders the cylinder may be of a constant diameter or it may be stepped. That is one piston larger than the other. The wheel cylinder may be either inside or outside of the brake shoe.

The hydraulic brake system is so designed that pressure

as high as 6000 pounds per square inch can be used safely. A pressure of 1000 pounds per square inch should be sufficient to develop the necessary braking on a vehicle. When pressures over 1000 pounds per square inch is used, the life of the piston cup in both master and wheel cylinders is very much shortened.

When the hydraulic brake is used on large heavy-duty vehicles, it is necessary to use some auxiliary power to get the required amount of pressure on the large master cylinder. The large master cylinder is necessary in order to get the required pressure to move the large heavy brake shoes. This auxiliary power is usually obtained by the use of a vacuum booster or compressed air pistons.

Vacuum Boosters

The vacuum booster brakes make use of the vacuum created by the intake manifold of the engine to develop the power to expand the brake shoes. The vacuum of the intake manifold varies with the speed of the engine. The advantage lays in the fact that the vacuum is the greatest when the engine is running in "compression" which is also the time that the maximum amount brake effort is desired. The vacuum boosters may be either piston or diaphragm type.

The vacuum booster on a gasoline engine can get the required amount of vacuum from the intake manifold, but in a diesel engine there is not sufficient vacuum in an intake manifold under any operating conditions and it is necessary

to install some type of engine driven vacuum pump. Vacuum boosters are used almost entirely with hydraulic brake systems. There are one or two trucks that now use the vacuum boosters directly on the brake arms. On trailer brakes the vacuum boosters are used practically universally in direct connection.

The atmospheric suspended type and the vacuum suspended type are the general types of vacuum boosters.

The atmospheric type is the simpler of the two. When the booster is in the "off" position, there is an atmospheric pressure of 15 pounds per sq. in. on each side of piston. One side of the piston is connected with a vacuum and when the valve is opened, the pressure is reduced to approximately 5 pounds per Sq. in. This forces the piston to the end of the piston toward the vacuum. When the valve is closed the piston is open to the atmosphere again so that the pressure goes back to normal on both sides of the piston and a spring draws the piston back into normal position.

In the vacuum suspended system the piston is held in position by a vacuum on both sides of the piston when in an "off" position. When the brake valve is opened, one side of the piston is opened to the atmosphere pressure while the other is still connected to the vacuum. The piston then moves toward the end with the vacuum. When the brake valve is closed the end of the piston that has been open to atmosphere pressure is connected with the vacuum and equal pressure on both sides of piston results and the retractor

spring pulls the piston back to normal position.

The atmospheric has the advantage of being the cheapest type but in this system once the source of the vacuum is lost the booster becomes inoperative. Although the vacuum suspended system is more expensive, it is also a more desirable brake in that if the motor fails there still is enough power in the booster to help in making a stop. The vacuum suspended system is not as likely to stall a motor because it injects about one third as much air suddenly into the manifold as does the atmospheric system.

There is a new product called the "hydradac" which combines the vacuum booster and hydraulic master cylinder into one self contained unit. Probably will not be available until after the war.

A great deal of care should be taken in handling trailer hose connections etc. because all the dirt that gets into a vacuum booster system eventually gets to the motor. This will cause an engine to wear out before its time. This condition can be aided by the use of aircleaners at the air intakes.

In order that any vacuum power brake be safe and under control it must.

1. Respond instantly in any desired amount
2. Maintain a constant reserve power -- accomplish this by the use of large supply lines from the reserve tank to motor manifold and a reserve tank three times the capacity of the power chamber.
3. Large capacity valves between supply tank and power chamber.

4. Large diameter vacuum lines between supply tank and power chambers.
5. Small diameter control lines between hand valve and remote valve.
6. An emergency brake away valve that in event of either or both supply and emergency control lines become suddenly disconnected the trailer brakes will apply at least 75% of their maximum power and hold the brake for several hours.

Air Brakes

The air brake is the one that is probably best suited for braking conditions such that are found on most logging operations. With the air brake there is a greater available stopping power, more rugged construction of drums, shoes, and lining, and this type of brake can be used on a train of vehicles.

All air braking systems consist of generally of an engine driven air compressor, an air reservoir, brake operating mechanism, and control valves.

The engine driven air compressor may be of the reciprocating piston type or rotary type. The most common type is the reciprocating two cylinder type as put out by the Westinghouse Air Brake Company. There is also a three cylinder compressor. The two cylinder type has a nominal rating of about 7 cubic feet of free dry air per minute at rated speed and the three cylinder type has a nominal rating of 12 cubic feet.

The Westinghouse compressors can be had in either the independently oiled or engine oiled type. They may be either

air-cooled head or water-cooled head type. The water-cooled are designed for higher rates of speed and are the usual type found on heavier equipment.

The air compressors have to be kept practically free of dust. Small dust particles that enter the air compressor, due to the high temperature present, will tend to form carbon. This carbon is deposited on the valves and discharge piping.

The air reservoirs are usually the cylinder type and are installed on both truck and trailer. All reservoir tanks should be equipped with blow-off cocks in order to remove the moisture that has condensed out of the air.

The brake operating mechanism may be either diaphragm or piston and cylinder type. Because of high air pressures and short stroke of the braking mechanism the diaphragms are the most common type. By the use of a slack adjuster on the brake arm in connection with the diaphragm it is comparatively simple to make accurate brake adjustments.

As to control valves, the air brake system should be equipped with the following seven control valves.

1. Foot valve -- takes place of the ordinary brake pedal. Should be designed so that the pressure builds up directly to the proportion the foot valve moves. This valve is primarily for the truck brakes but may be attached to the trailer brakes.
2. Hand control valve -- used to set the brakes on the trailer. Should be of the graduate pressure type so that the amount of pressure applied on the brake shops is directly proportional to the movement of the valve control lever.

3. Relay valve -- designed to take air pressure from controlling mechanism and release air to operating mechanism. Relay valves are installed adjacent to the brake diaphragms which allows full line pressure within a few feet of the diaphragm. This reduces lag between brake application and operation. This valve is used on trailers where the air reservoir tank is mounted on the trailer, and also used on the rear axle of six wheeler trucks.
4. Quick release valve -- designed to permit the rapid release of air as soon as the application is stopped without the necessity of air returning to the control valve. This valve has special application on the front wheel brakes. In case the front wheels lock when the brakes are applied it may be possible to regain steering control through the rapid release.
5. Front wheel limiting valve -- this is a valve by which the amount of pressure going to the front diaphragms may be regulated from full down to zero pressure. This control valve is of considerable importance where there is danger of locking the front wheels due to the presence of ice, snow, or mud on the road.
6. Emergency Break away valve -- this valve sets the brakes on the trailer any time the air line connecting the truck and trailer is broken or disconnected.
7. Double check valves -- this is a valve by which the brakes on the trailer can be controlled by either the foot valve or hand control valve.

The air brake is not only a good brake but has several safety features that are not in other braking systems.

The double check valve has the advantage that both truck and trailer brakes can be operated from the foot valve. The driver has to use only one set of brakes instead of two as he would in a system of separate trailer brakes. By using all the brakes on truck and trailer at the same pressure would keep from over loading one set of brakes. The over loading of one set may cause excessive temperatures and failure in that set.

Emergency Brakes

Most of the American built heavy duty type trucks are equipped with an emergency brake built into the drive lines. There are two types -- disc and drum. Both types are mechanically operated by the emergency brake lever. They are not for the purpose of stopping but a "parking" brake. If these brakes are used for stopping, there may be considerable damage caused to the running gears due to the fact that these brakes operate on the driving lines.

An emergency brake should be so installed that it will operate at all times. That is it should be installed behind any auxiliary transmission on trucks with more than one transmission. This eliminates the possibility of having an ineffective brake because of the auxiliary transmission being in neutral.

Dynamic Brake

The "Hydrotarter" for truck use has been developed and is essentially a water brake. The "Hydrotarter" consists of a metal housing containing a wheel, or "roter" with fin-shaped spokes. The housing proper has fin-shaped spokes opposing those on the wheel and have a clearance not less than .003 inch. Water is introduced between the stationary and moving elements and a resistance is set up which is proportional to the amount of water that is admitted. This resistance results in heat being added to the water. This heat is dissipated by circulating the water through the engine cooling system. As this would be operating on down

grades, the cooling would be able to take care of this heat because it is not operating at its maximum capacity.

The "Hydrostarter" does not take the place of a service brake, but is for the purpose of controlling the speed on down hill grades. The "Hydrostarter" also imposes loads on the rear axle that does not usually occur and may cause a more rapid wear on the rear end gears. The wear would, however, come on the opposite side of the gear teeth from the drive side.

As yet the "Hydrostarter" has not been used on logging trucks, but it may be a solution to the increasing brake problems.

New Type Truck Brake

This new truck brake has been developed by the Kenworth Motor Truck Corporation of Seattle, Washington. It is really just new developments on an old type brake.

This new brake is $16\frac{1}{2}$ " in diameter by 7" wide on the rear axle and $16\frac{1}{2}$ " x 5" on the front wheel. Uses a $\frac{3}{4}$ " thick molded block-type lining of high friction type.

The 7" rear drums are cast of special alloy iron which has remarkable ability to withstand the punishment given to a brake drum. The $16\frac{1}{2}$ " drum diameter allows ample drum thickness and the use of general cooling ribs. At the same time space for air circulation is provided between drum and wheel. These features permit rapid dissipation of heat, the most important factor in providing long lining and drum life.

Aluminum brake shoes increase the speed of heat dissipation, at the same time serving to reduce weight. The shoes are heavily ribbed to guarantee rigidity and proper alignment at all times.

Quick application and quick release can be obtained only by reducing friction in the application mechanism to a minimum. In these new brakes, the Westinghouse air diaphragms are direct-connected to the slack adjuster levers, without the usual bell cranks and rods, thus greatly reducing the amount of linkage and friction. The diaphragms are mounted with the rod end down to prevent the entrance of dirt and water. The camshafts are mounted in needle bearings, sealed against the entrance of dirt and water. The "S" type cams work against nitrided roller cam followers which rotate in the shoe heads. All of these features combine to reduce friction and maintenance expense.

To provide for quick, easy adjustment, Westinghouse enclosed worm and gear slack adjusters are used.

This type of brake is exclusive with Kenworth.

CHAPTER III

Maintenance

When considering the subject of maintenance of a brake system it is necessary to look at all of the things that influence the cost of maintenance. The different factors will be discussed under the following heads -- Brake drums, Brake lining, Unbalanced brakes, Brake cooling.

Brake Drums

The material used in brake drums is not the important thing but the physical characteristics. Brake drums are made of either cast iron, steel or aluminum, with some additives to get the proper grain structure. The most common type is the cast iron.

The largest possible drum size which can be fitted inside a 20" diameter wheel is the $17\frac{1}{4}$ " drum. Recently the trend is toward a $16\frac{1}{2}$ " drum in order to have more air space around the drum for cooling.

The most common causes of brake drum failures are checking, cracking, bell mousing, and excessive wear.

Checking or commonly known as "heat checking" is the checking of the inside surface of the brake drum due to excessive temperature. This excessive temperature may be caused by unbalanced brake or over load.

Cracking of brake drums may be caused by suddenly changing the temperature of the brake drum such as occurs when water is thrown onto a hot drum. Heat checks will

develop into cracks if a heat checked drum is operated.

Bell mouthing is where the open end of the brake drum is larger than the closed end. This condition arises where the structural strength is too weak to stand the pressure imposed by the brake shoes. Bell mouthing is found usually in the extremely wide brakes. Another failure of the brake drum is the egg-shaping of the drum. Both bell mouthing and egg-shaping will cause early drum failure and excessive lining wear due to the uneven distribution of pressure of the shoes against small areas.

Excessive wear of brake drums may be caused by improper lining or dust. The dust works as an abrasion in the drum and may be eliminated to some extent by the use of dust shields. These dust shields have the disadvantage of cutting down some of the air circulation past the brake shoes.

Brake Lining

The brake lining on a truck brake is one of the essentials that have had considerable amount experiment work done on them. There are four major types. There are 109 woven brands, 17 molded fabric brands, 89 molded bonded fibre brands, and 29 friction block brands. This is a total of 244 different brands.

The basic material of all brake lining is asbestos. In a woven lining the longer asbestos fibers are combined with cotton. In a moulded lining the short fibered asbestos is mixed with a bonding material that results in a dough like substance that is heated, pressed and ground into the shape of brake lining. Heavy duty trucks and trailers use mostly

a molded type lining.

Since the frictional force is applied to the brake drum through the use of brake lining, the coefficient of friction is fundamental to good design. The coefficient of friction can also be considered as a measure of efficiency of the friction.

Brake lining failures can be classified into complete loss of friction, unnecessary fast wear, disintegration, and defective lining.

Complete loss of friction caused by:

1. Grease-soaked lining
2. Glazing
3. Burning-in
4. Lining completely worn out
5. Linkage hitting obstruction
6. Frozen linkage
7. Blocked hydraulic line
8. Stuck hydraulic piston
9. Piece of dirt under master cylinder rubber
10. Clevis pins dropped out of linkage

Unnecessarily fast wear caused by:

1. Undersize and overloaded brakes
2. Scoring
3. Dragging but not overheating brakes
4. Unequal brake adjustment
5. Unusual frequency of fast stops

Disintegration of brake lining caused by:

1. Raveling
2. Softening or pulverising
3. Ply separation or tearing
4. Pulling from rivets

Defective lining will have one of the following conditions:

1. Too thick or blistered
2. Curvature not right
3. Drilling incorrect
4. Brittle in cold water or on aging.
5. Difficult to handle

The life of brake lining is effected a great deal by the width of lining used as is shown in the following example.

A truck logging operating in the Douglas fir coast area was hauling on a 3 mile haul with $2\frac{1}{2}$ miles of 10% to 18% favorable grade and averaging from 6 to 8 trips per day. Using $\frac{1}{4}$ " x $3\frac{1}{2}$ " lining on a $17\frac{1}{4}$ " drum, the life of the lining was from 10 to 14 days. He then changed to $\frac{3}{4}$ " x 6" on a $17\frac{1}{4}$ " drum and the life was one year. Both linings were of the same type. In making this change it was necessary to change the drums, but this added cost was more than taken care of by the lowered maintenance cost.

Unbalanced Brakes

Any brake required to do more than its predetermined built-in capacity will result in trouble. The vehicle will experience rapid lining wear, high brake temperature, scored brake drums, heat checks, tire trouble, wheel bearing trouble, noisy brakes etc. Much of this trouble can be avoided by balancing brakes. This is more than having the brakes on one axle adjusted, but having both right and left hand brakes adjusted.

Balanced braking requires proper installation of correct size brakes and power unit for the load being carried and also includes periodical inspections and maintenance. Some of the conditions that might contribute to the unbalancing of a brake are:

1. Wheel bearing out of adjustment, causing eccentric brake drums
2. Eccentric brake shoes due to poor adjustment.
3. Grease or oil on brake lining
4. Loose brake drums
5. Brake drums scored, bellmouthed, or eccentric.
6. Loose brake support.

7. Irregularly worn brake lining
8. Loose liner rivets
9. Dust in brake
10. Loose or leaking hydraulic wheel cylinders
11. Swollen hydraulic piston cups
12. Leakage in air, hydraulic or vacuum lines
13. Kinked connecting hose
14. Worn diaphragms, in brake power units
15. Faulty relay valves
16. Faulty retractor spring
17. Clogged valves
18. Dirty hydraulic brake fluid.

Brake Cooling

One of the big problems in braking is the dissipation of heat. The logging industry is the only industry that extensively uses water on the brake drums to increase the capacity of brakes.

To avoid disastrous results, the water must be applied to the brakes before the brakes heat up and the flow of water must be stopped before the truck comes to a standstill with hot brake drums. Drum crack is caused by sudden changes in temperature.

Norman C. Williams of Portland, Oregon invented an automatic system that when a vacuum is applied to operate the brakes, a connection from the line operates a diaphragm in this device which causes a valve to open allowing the water to enter from a supply tank into a line supplying the brakes. This has the advantage of putting the water on the drums at the proper times but there is no way for the driver to tell if all of the drums are getting water.

The gravity system is the simplest type but usually requires the driver to stop or start the water. This

system has the advantage that the flow of water can be checked on by the driver before he starts using the brakes. This system has the advantage that the flow of water is continued longer than should be because the driver has to stop the truck before the flow can be stopped.

There are two other methods of applying water that would be controlled from the cab and would work on the same principle as the vacuum type described above. These types are air pressure system and a propeller shaft or power driven pump. It is believed that the power driven pump would do a better job in distributing the water, and at the same time would be a cheaper installation than to keep adding air compressor capacity in order to compensate for the improper use of air. This matter will have to be worked out in the interest of safety of operation.

In some cases there has been trouble with small multiple cracks forming in the brake drum due to the water cooling the outside while the shoe is heating the inside, occasionally resulting in drum breakage. The remedy for this trouble was to pipe water inside the drum, where it will have direct contact with brake shoe as well as inside drum.

The putting of water has its disadvantages. The Pointer-Willamette Trailer company have made extensive test using various linings to determine friction losses where water is applied inside the drum. In most cases Pointer-Willamette Equipment Co. states, "the loss seems to be

about 20%, in other words it requires a longer brake lever or in the case of vacuum control, larger boosters to stop the same loads when water is applied directly to the linings. However, considerably longer life for the linings has been obtained in most cases."

The use of water on brakes in winter has caused some trouble due to the freezing of the water in the supply tanks and water lines. This situation was remedied by cutting out the use of water and slowing down the speeds. In freezing weather the atmosphere will take care of considerable more heat dissipation.

Some operators believe that water should not be used. L. A. Christenson of Seaside, Oregon will not use water unless the heat being dissipated from the brakes heat up the rims so much that they are melting the tubes in the tires. He has not used water since 1923 and from that time up to the present has had two drums break. And still Mr. Christenson has a comparatively low maintenance cost on brakes.

Records such as those made by Mr. Christenson are probably better than any made on operations using water, but the use of water on brakes in logging is with us to stay because it makes descending of grades faster than would be otherwise possible.

CHAPTER IV

Legal Restrictions

In view of State and Federal brake laws constantly becoming more stringent the operator of today should demand brake equipment which complies with brake laws throughout the country to prevent high maintenance and early obsolesences.

Most state laws and the regulations of the Interstate Commerce Commission contain the following requirements:

1. The brakes on the vehicle must be adequate.
2. Two separate means of applying brakes must be provided, which are independently controlled.
3. The vehicle or combination of vehicles must be capable at all times and under all conditions of loading of stopping within certain specified distances when traveling at certain specified speeds.

CHAPTER V

Conclusion

The problem of braking and brake maintenance is definitely becoming a more prominent feature with the use of larger trucks, higher speeds, rough logging shows, etc.

There are several possible ways in which braking can be increased and the cost of brake maintenance reduced.

These ways are:

1. Through the education of drivers. That is getting the drivers to inspect their brakes often and to use them correctly.
2. Through the proper use of water -- that is the application of water at the proper time.
3. The development of new types of brake drums and lining.
4. The development of a device that will show the driver if the water is getting to each individual brake drum.
5. The use of large single wheels in place of the present dual wheel. This has two possibilities.
 - a. The use of a larger drum on the larger wheel to give more braking surface.
 - b. The use of the same size drum that is used on the present 20" diameter wheel so as to give better air circulation which will result in better heat dissipation.

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