Sept. 25, 1962 R. S. SANFORD ETAL 3,055,458

LIQUID COOLED FRICTIONAL MECHANISM

Filed Dec. 30, 1957 3 Sheets-Sheet 1

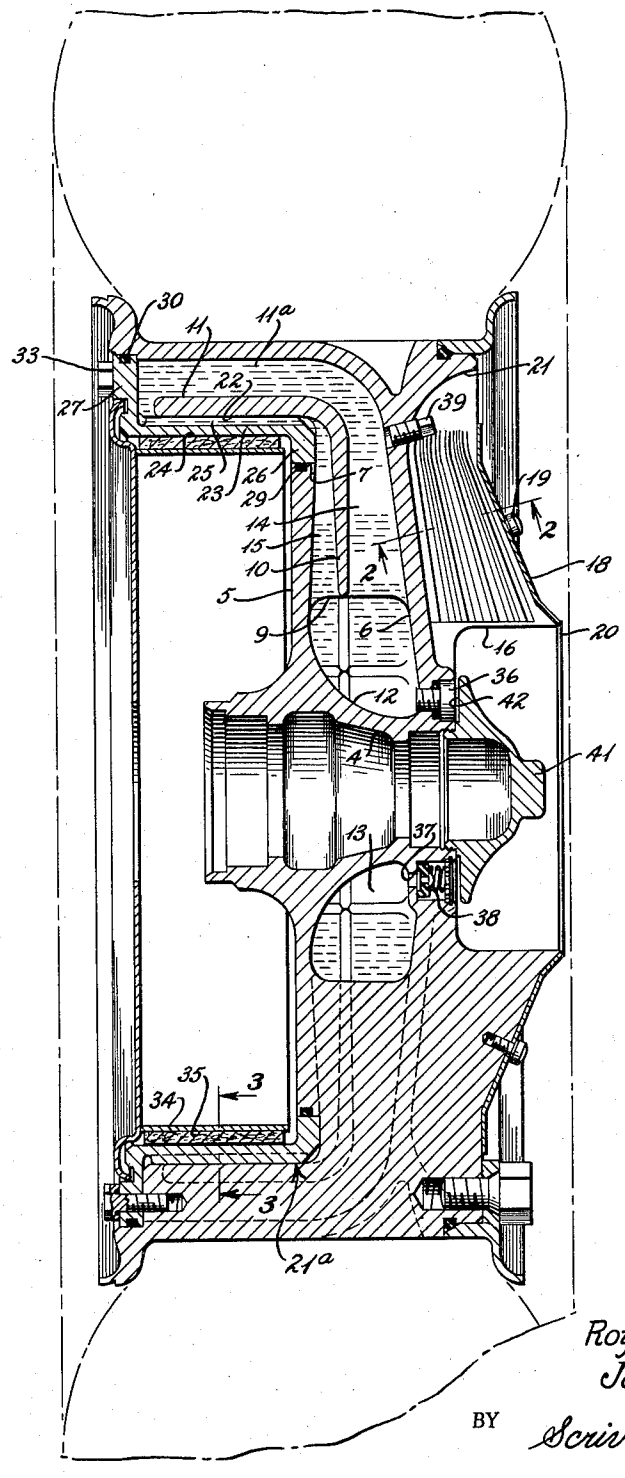


Fig. 1

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Filed Dec. 30, 1957 3 Sheets-Sheet 2

Fig. 2

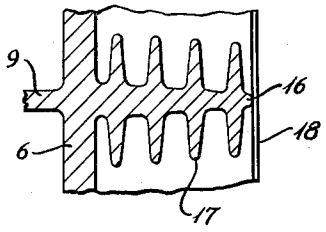


Fig. 3

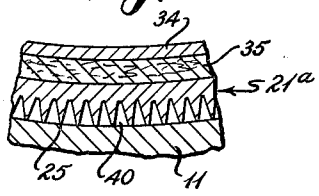


Fig. 5

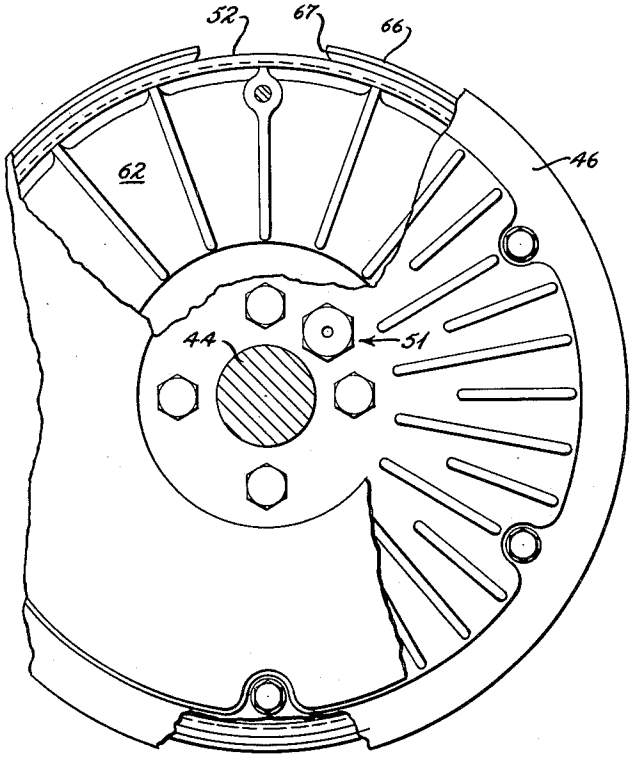
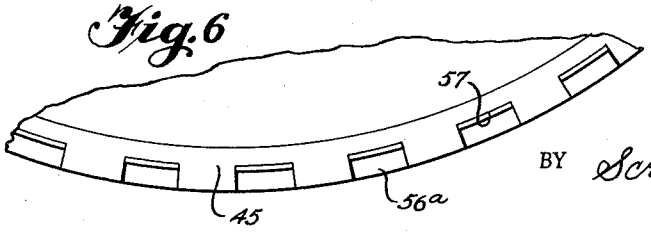


Fig. 6



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LIQUID COOLED FRICTIONAL MECHANISM

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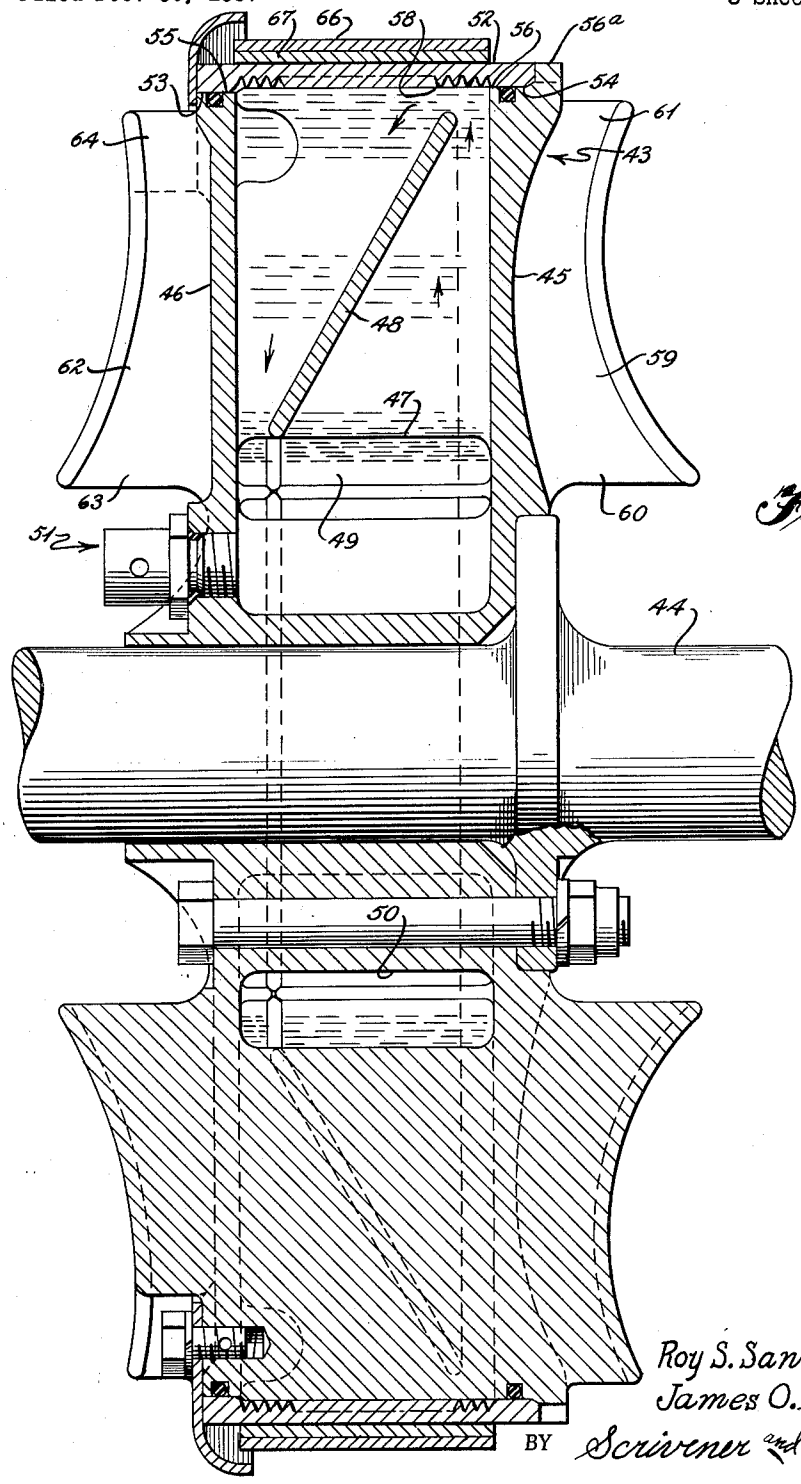


Fig. 4

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3,055,458

LIQUID COOLED FRICTIONAL MECHANISM

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Filed Dec. 30, 1957, Ser. No. 706,034
2 Claims. (Cl. 188—264)

This invention relates to frictional mechanisms, hereinafter generally referred to as brake mechanisms, and more particularly to brake mechanisms of the liquid cooled type.

The excessive heat developed in friction brakes has caused great difficulties in the past, and it is accordingly one of the objects of the invention to provide means for overcoming these difficulties.

Another object of the invention is the provision of novel brake cooling means.

Yet another object of the invention is the provision of brake mechanism of the above type, wherein the liquid cooling means is self-contained in the brake mechanism itself.

A further object of the invention is to provide, in a brake mechanism of the above type, means for automatically circulating the cooling liquid in the brake mechanism.

A still further object of the invention is to provide brake mechanism of the above type, wherein the cooling liquid continues to circulate in the mechanism when the vehicle wheel is stationary.

Another object of the invention is to provide a self-cooling brake drum wherein cooling liquid is forcibly maintained in engagement with a surface directly opposite to the friction surface.

A further object of the invention is to provide a novel method of filling a hollow brake drum with liquid and preparing the drum for use on the vehicle.

Another object is the provision of a novel composite brake drum.

These and other objects of the invention will be more readily apparent from the following detailed description when taken in connection with the accompanying drawings. It is to be expressly understood, however, that the description and drawings are not to be taken as defining the limits of the invention, reference being had for this purpose to the appended claims.

In the drawings,

FIG. 1 is a sectional view of a brake drum constructed in accordance with the principles of the invention;

FIG. 2 is a fragmentary section of a portion of the structure of FIG. 1 taken along line 2—2 of that figure;

FIG. 3 is a fragmentary section of another portion of the structure of FIG. 1 taken along line 3—3 of that figure;

FIG. 4 is a sectional view of a modification of the invention;

FIG. 5 is a side elevation of the structure of FIG. 4 taken from the left and partially broken away, and

FIG. 6 is a fragmentary view of the mechanism of FIG. 4 taken from the right end of that figure.

Although the matter of liquid cooling for vehicle brakes and brakes of other types has received considerable attention in the past, many of the systems proposed have involved considerable piping or plumbing, and have also required the use of a circulating pump of some sort to circulate the liquid through the mechanism. It has been found that in many cases, however, adequate cooling may be provided by using a properly constructed brake drum or wheel having a chamber for cooling liquid therein which is self-contained in the brake drum without any

outside connections, and with provision being made for circulation of the cooling liquid within the drum in order to impart the heat of braking to the entire metal structure of the drum or wheel. The construction set forth in the present application is adaptable to either a brake drum or a wheel, and the terms are used herein interchangeably, and without limitation as to the exact configuration of the brake drum or wheel. In a broad sense, the above terms refer to a rotating member adapted to be frictionally engaged by a brake shoe or brake shoes, and having a chamber for cooling liquid therein with provision for circulating the cooling liquid within the drum.

The brake drum is preferably constructed in such a manner as to include a separate metallic friction element having one surface adapted for engagement by a brake shoe, and a surface directly opposite thereto adapted for engagement by the cooling liquid within the brake drum, but it is to be understood that in some cases, the element may be made of iron or steel, and may be made as an integral part of the brake drum if desired. In the preferred form of the invention, however, a separate friction element is utilized as above referred to, and this element is preferably made of high thermal conductivity metals such as copper, silver, and some of the high-conductivity alloys thereof, it having been found that these metals have very good friction and wear characteristics when used with a low heat conductivity composition lining, while at the same time serving to conduct heat rapidly from the friction surface to the cooling liquid in order to prevent overheating of the drum friction surface and the adjacent brake lining.

Referring first to FIG. 1 of the drawings, a wheel is illustrated for convenience, but it will be understood that the wheel illustrated can be readily utilized with minor external changes as a separate brake drum to which a wheel may be attached. Consequently, in the following description the mechanism will preferably be referred to as a drum or brake drum. The drum is hollow and includes a hub portion **4** having spaced apart walls **5** and **6** extending radially outward therefrom, the wall **5** having a cylindrical outer surface **7** concentric with the axis of the drum, and the wall **6** merging into a cylindrical portion **8**, also concentric with the axis of the brake drum, the wall thus being cup-shaped. The walls **5** and **6** are connected by means of a plurality of thin fins **9** extending radially outward between the walls and also connecting the walls with a continuous cup-shaped partition or baffle **10** extending around the entire drum as shown, and merging along its outer portion with a cylindrical portion **11** concentric with the cylindrical portion **8**. Thus a closed cooling liquid chamber **11***a* is formed in the drum. As shown in the drawing, the inner edge of the baffle terminates in a region spaced radially outward from an outer surface **12** of the hub, the fins **9** also terminating in this region. Thus a reservoir for cooling liquid **13** is provided entirely surrounding the outer surface **12** of the hub and communicating with passages **14** formed between the wall **6** and the baffle **10** as well as with radial passages **15** formed between the baffle **10** and the wall **5**. The outer surface of the wall **6** is provided with a plurality of radial fins **16**, and as shown in detail in FIG. 2, these radial fins are provided with additional cooling fins **17**. A substantially conically shaped cover plate **18** is secured to the ribs **16** by means of suitable screws **19**, the plate having an air intake opening **20** in the center, and terminating at its outer periphery in a region spaced radially inwardly from outer periphery **21** of the brake drum. Thus, when the drum is rotating, the drum structure with the spokes and the plate **18** provide a centrifugal blower which takes air into the opening **20** and discharges it in the annular space between the drum portion **21** and the periphery of the conical plate **18**, this centrifugal pump or blower

serving to provide a rapid air circulation along the fins **16** and **17** to effectively remove heat from the wall **6** of the drum.

In the embodiment shown, a friction element **21***a* is formed as a separate member secured to the drum, and may be made of one of the preferred metals previously described or of some other suitable metal, depending upon the type of service required. It is to be understood, however, that if desired, this element may be formed as an integral part of the drum structure, provided that structure is made of a metal having suitable friction characteristics. The cylindrical partition portion **11** is formed with an inner cylindrical surface **22** concentric with the axis of the hub and adapted to support the separate metal friction element. The metal friction element includes a cylindrical portion **23** having an inner cylindrical surface **24**, and having a plurality of directly adjacent V-shaped teeth **25** formed on the outer surface thereof and extending generally axially of the drum. The right end of the friction element is provided with an inwardly extending flange portion **26** adapted to slidably engage the surface **7** on the wall **5**, while the left end of the element is provided with an outwardly extending flange portion **27** adapted to slidably engage a bore **28** formed on the inner surface of the cylindrical portion **8** of the drum. Leakage between the flanges and the drum is prevented by O ring seals **29** and **30** positioned in suitable grooves formed in the cylindrical surface **7** of the wall **5** and in the outer surface of the flange portion **27** of the friction element. The right side of the flange portion **27** abuts the left ends of the fins **9**, and the flange is secured in position against these fins by suitable cap screws **33**. The metal friction element is so installed as to insure that the surfaces at the ends of the teeth **25** are in intimate engagement with the cylindrical surface **22**, in such a manner that the portion of the friction element which is engaged by the brake shoe is mechanically supported by the partition portion **11**. The surfaces at the ends of the teeth on the friction element should be narrow at their point of engagement with the surface **22**, and if desired may be contoured to provide a substantially tangential line contact between the teeth and the surface **22**, thus insuring that substantially the entire surface area of the teeth will be exposed to the action of cooling liquid. A suitable brake shoe or brake shoes **34** may be provided and actuated in well known manner to effect engagement of brake lining **35** with the inner surface of the cylindrical portion of the friction element.

With the brake drum assembled as shown, liquid may be introduced into the interior thereof by means of a filler plug **36**, located in the extreme right hand portion of the reservoir **13**, for purposes to be more fully described hereinafter. The preferred method of filling the wheel is to lay the wheel on its side with the axis vertical and the filler plug uppermost, and then entirely fill the wheel with the selected cooling liquid. The plug is then re-inserted, and the wheel is placed in an oven and heated to a temperature approximating that of which the brake drum will operate in service. It will be noted that an outlet port **37** is also provided in the chamber **13** adjacent the extreme right end thereof, and that this port is normally closed by a spring biased relief valve mechanism **38** as shown, this mechanism being operable to prevent the escape of liquid or vapor from the chamber **13** until a predetermined pressure is reached, this pressure being determined by the construction of the relief valve mechanism. It will be understood that any pressure can be utilized by properly selecting the components of the relief valve mechanism. With the drum filled and placed in an oven as above described, the heat will expand the liquid in the drum and exert a pressure sufficient to discharge a certain amount of liquid therefrom. Thereafter, in the event the drum is maintained at a given temperature in the oven, vapor or steam will be formed and a certain amount of this will also be discharged

through the valve. Eventually, however, a condition of balance will be reached, wherein the chamber **13** contains liquid and vapor or steam at a pressure determined by the setting of the valve mechanism **38**, and no further vapor or liquid will be discharged. The wheel is then cooled down to normal or ambient temperature, whereupon a vacuum is produced in the reservoir **13** and in the adjacent passages, leakage of air into the drum being prevented by the closed filler plug **36** and the relief valve **38**.

From the foregoing, and assuming by way of example that a temperature of 350° F. has been chosen for the oven temperature, it will be apparent that when the wheel is in operation, no steam or vapor will be discharged from the brake drum through the valve **38** until the temperature of the liquid in the drum again reaches approximately 350°. If this temperature is appreciably exceeded, a slight additional amount of steam or vapor may be discharged, and a new condition of balance will be reached.

In some cases, it may be satisfactory to merely put a measured amount of cooling liquid into the brake drum, this being of course done through the filler plug **36** with the wheel again horizontal. If it is desired to insert liquid into the wheel in service, this may be done through a filler plug **39**.

When the drum is rotating, it is obvious that the liquid in the drum will be thrown outward by centrifugal force, and in the interest of proper circulation, it is essential that there be at least enough liquid in the wheel to assume, with the drum rotating, a level along the lines of that shown in the drawing. In other words, it is essential that the inner ends of the fins **9** and the inner periphery of the partition **10** be well covered with the liquid when the wheel is rotating.

Assuming that liquid has been introduced into the wheel or drum as above described, it will be noted that the valleys between the teeth **25** form, in conjunction with the cylindrical surface **22** of the partition **11**, passages **40** for cooling liquid extending from the left end of the drum member to the right end. The passages **15** communicate with the passages **40** at the right end thereof, and the passages **14** communicate with the passages **40** at their left ends. As the brake shoes engage the inner surface of the friction element, the friction element is heated, and consequently the cooling liquid in engagement with the teeth **25** in the passages **40** is heated and becomes lighter in weight. Hence, this liquid tends to flow through the passages **40** and the passages **15** toward a region of lower pressure in the reservoir or chamber **13** near the center. At the same time, the liquid in the reservoir **13** is cooler, and therefore heavier than the liquid in the passages **40**, and due to the rotation of the wheel, is thrown outward by centrifugal force through the passages **14**, and into the left ends of the passages **40** between the teeth. Thus, assuming that there is an ample supply of liquid in the chamber **13** sufficient to cover the inner ends of the fins **9** and the inner periphery of the partition **10**, a thermo-syphon flow will be set up as soon as the friction element is heated by the application of the brake shoes. This action will continue as long as the wheel is rotating and there is a temperature differential between the liquid in passages **40** and that in the chamber **13**. If the vehicle is stopped following a braking action, it should also be noted that the thermo-syphon action will still continue in the lower portion of the wheel, the extent of this action and the portion of the wheel in which it occurs being dependent upon the amount of liquid in the drum. In any case, and particularly in the event the above described high-conductivity metals are utilized for the metal friction element, the entire drum will be cooled by this action even when stationary due to the lateral heat transmission characteristics of the friction element metal.

Due to the thermo-syphon circulation occurring when the wheel is rotating, it will be understood that substan-

tially the entire metal structure of the drum or wheel will be heated relatively uniformly, and that this entire structure will be effective not only to store heat as a heat reservoir, but also to dissipate this heat to the surrounding air. In the case of the ordinary brake drum having no liquid therein, it will be apparent that this situation does not occur, as due to the heat-conductivity characteristics of the metal, regardless of the metal utilized, the portions of the drum remote from the friction surface will be much cooler than the friction surface itself, and therefore only a small portion of the drum structure will be heated to a sufficiently high temperature to effect efficient heat transfer to the surrounding air. Thus, the result sought in the present invention is a structure wherein all of the metal in the structure is heated more or less uniformly to a temperature which is lower by considerable than the temperature of the friction surface in a drum of the conventional type which does not contain the cooling liquid. The present invention achieves a lower temperature at the friction surface itself, and this is an extremely important feature, as most of the difficulties experienced with the conventional brake linings and in conventional brakes at the present time are due to the extremely high temperatures which occur directly at the interface between the brake lining and the rotating friction element. In conventional brakes the high temperature drop between the friction surface and other portions of the brake drum causes difficulties due to expansion, resulting in cracking or checking and other well known troubles, these being eliminated by the present invention.

Another important feature of the invention resides in the location of the liquid reservoir or chamber 13 directly adjacent the outer surface 12 of the drum hub. Since the embodiment shown in FIG. 1 relates to a brake of the so-called internal expanding type, it is essential that means be provided for maintaining liquid in direct engagement with the outer surface of the friction element directly opposite the friction surface 24, and this can only be done by having a supply of liquid available in the more central portion of the drum which can be thrown outward by centrifugal force when the wheel is rotating in order to contact the friction element as above described.

It is also essential in constructing a drum of this type to make the liquid containing portions of the drum of such symmetry that when the drum is rotating and the cooling liquid is displaced outwardly by centrifugal force as indicated in the drawing, the liquid does not act in any way to throw the wheel out of balance. If the liquid containing portions of the drum are properly shaped and arranged, no unbalanced condition is caused by the liquid except at very low drum rotational speeds when the centrifugal force is insufficient to throw the liquid outward in the manner shown in the drawing. It will be understood, however, that these rotational speeds are very low indeed, and that conditions of unbalance are not noticeable to the vehicle operator at such speeds.

In further explanation of the thermo-syphon cooling action, it is pointed out that in the drum shown, the pressure on the liquid, due to centrifugal force, is much greater in the outer part of the drum than it is in the chamber 13. Consequently this drum may be compared to a kettle of boiling water, wherein the steam bubbles tend to rise to the top of the kettle, or to a region of lower pressure, and in the same manner, any steam bubbles formed in the brake drum of the present invention tend to migrate toward the center of the drum since this is a region of lower pressure.

In the event a brake drum is made in the form of a wheel with the tire mounted directly on the outer surface of the wall 8, it should also be noted that due to the direction of the thermo-syphon flow of the cooling liquid, the cooler liquid is thrown outward through the passages 14 and along the inner surface of the wall 8, thus effectively preventing over-heating of the wall 8 and consequent damage to the pneumatic tire on the rim. A hub cap 41 may be secured to the right end of the hub as shown in order to close the opening in the hub and at the same time serve as a protection for the relief valve assembly 38. To this end, a surface 42 is formed on the left end of the hub cap and spaced from the right face of the hub in the region of the relief valve assembly and spaced from the opening of the relief valve sufficiently to permit the discharge of steam or vapor between the surface 42 and the relief valve opening, while at the same time effectively preventing the entrance of dirt and other foreign matter into the relief valve assembly.

In the preferred embodiment of the invention, the main portion of the drum or wheel is preferably made from a light and relatively high-thermal-conductivity metal such as aluminum, magnesium, and some of the well known alloys thereof. It is a well known fact that it is very important in the interest of good riding qualities, particularly on a pleasure car, to keep the unsprung weight down on the vehicle and this can be done by the use of aluminum or magnesium wheels. Aluminum and magnesium and the alloys thereof, however, are not ordinarily satisfactory as friction materials due to the metal structure and to the relatively low melting points of the metals, and in general it has been found to be entirely unsatisfactory to utilize such metals in direct engagement with a composition friction lining, commonly known as brake lining. The heat storage capacity of the drum or wheel is also very important and should be as large as possible. The specific heats of certain materials of interest in connection with this invention are listed below as follows:

Water	1.000
Aluminum	.224
Copper	.0918
Iron	.122
Magnesium	.248

From the foregoing, it will be seen that although copper might be used for the entire drum and wheel structure, this is undesirable from the standpoint of heat storage capacity since the specific heat of copper is very low compared with the other materials listed, and in addition, copper lacks the necessary strength. Iron or steel can be utilized, but here again the heat storage capacity is very low compared with metals such as aluminum and magnesium which have twice the heat capacity or better. Water has the highest heat capacity of all, and thus it will be seen that for a given weight of wheel or drum, the outstanding benefits of the high-thermal-conductivity metals hereinbefore defined, when used in conjunction with relatively non-heat-conductive brake linings, can best be realized by the novel combination shown wherein the main portion of the wheel or drum structure is made of light aluminum or magnesium having a high specific heat, together with an amount of copper of low heat capacity sufficient to act as the metal friction element only. Thus we have a heat reservoir in the wheel or drum which includes water or other liquid, and either aluminum or magnesium, all of which are not only lighter in weight than iron, steel or copper, but all of which also have much higher heat storage capacities for a given weight than copper. Thus the advantages of all of these components are combined in a novel and useful manner to provide a wheel structure having an unusually high heat storage capacity, together with means for dissipating a large portion of this heat from the structure by convection and radiation during and directly after a brake application. Although water has been referred to, it is contemplated that an anti-freeze mixture such as water and ethylene glycol may be utilized, this mixture having only a slightly lower heat capacity or specific heat than water. It will be understood also that other cooling liquids may be utilized if desired, but in any case, in order to prevent wheel un-

balance, the cooling liquid should not solidify under the conditions of operation.

In any case, the invention, when aluminum or magnesium is used, provides a wheel or drum structure having a very high heat storage capacity compared with conventional structures of this type, together with means for imparting heat to atmosphere and to the surrounding parts of the vehicle by convection and radiation. In the event copper or silver or some of the alloys thereof are utilized for the metal friction element, many of these metals are very ductile and lacking in strength, and means are provided by the present invention for adequately supporting these elements mechanically. A continuous circulation of liquid is provided by the thermo-syphon action due to the novel construction of the wheel or drum and the presence of the baffle **10** which directs the thermo-syphon flow in the proper direction. In view of the fact that the cooling medium in the wheel or drum is always either a liquid or a vapor, it will be evident that in the event the drum and the liquid chambers in the drum are originally symmetrical about the axis, there will be no tendency for an unbalanced wheel condition to occur as might be the case in the event a cooling medium such as salt were utilized, except at extremely low vehicle speeds at which no difficulty will be experienced due to such wheel unbalance.

FIGS. 4, 5 and 6 illustrate a modification of the invention heretofore described, the brake in this case being of the external contracting band type. Referring first to FIG. 4, a metallic friction element supporting member **43** is secured to a shaft **44** for rotation therewith, the member having spaced apart walls **45** and **46** connected by radially extending fins or spokes **47** as shown. A continuous conical baffle or partition **48** is also formed integrally with the fins for purposes to be more fully described hereinafter. The walls **45** and **46** form an annular cooling chamber **49** adjacent the central portion of the mechanism, bosses **50** serving to further reinforce the structure. A relief valve assembly **51** is provided in the wall **46**, this being, when the shaft **44** is vertical, as it may be in some installations, at substantially the uppermost part of the reservoir **49** and close to the axis.

Here again, it is contemplated that preferably one of the high thermal-conductivity metals, as heretofore defined, will be utilized for the friction element, and in this case, a cylindrical friction element **52**, formed of one of the above metals, is provided at the left and right ends with bores **53** and **54** slidably mounted on cylindrical surfaces **55** and **56** formed on the outer peripheries of the walls **46** and **45** respectively, suitable seals being provided as shown. The right end of the friction element **52** is provided on its periphery with lugs **56***a* adapted to engage corresponding notches **57** formed on the outer periphery of the wall **45**, thus serving to drive the friction element whenever the mechanism is rotating. If it is desired to increase the exposed surface on the inner surface of the friction element, teeth **58** may be formed integrally therewith. In order to provide a blower action and to more thoroughly dissipate heat from the walls **45** and **46**, the wall **45** is provided with radial passages **59**, these passages having openings **60** adjacent the center of the mechanism and opening **61** adjacent the periphery thereof. In like manner the wall **46** is provided on its outer surface with radial passages **62** having central openings **63** and peripheral openings **64**. Thus when the mechanism is rotating, air is drawn in through the openings **60** and **63** and discharged from the openings **61** and **64**, thus effectively extracting or dissipating heat from the walls **45** and **46**.

An external brake band **66** of conventional type is provided having an internal lining **67** thereon of a relatively non-heat-conductive material as heretofore described, and may be contracted by conventional mechanism, not shown, to effect engagement of the brake lining with the outer surface of the metallic friction element **52**. Prior to installation of the device, the interior of the brake drum mechanism is filled or partially filled with the cooling liquid as heretofore described in connection with the structure of FIG. 1, and the relief valve mechanism is then reinserted in order to prevent leakage of the liquid or vapor from the interior of the mechanism except when the pressure exceeds a predetermined value for which the relief valve is adjusted. With the mechanism rotating, it is contemplated that the level in the liquid, when thrown out by centrifugal force will be substantially as shown in the drawing, and in any case, it is essential in the interest of proper circulation of the liquid during operation, that the inner edges of the fins or spokes **47** and the inner periphery of the conical baffle **48** be well covered with the liquid as shown.

Assuming now that the brake has been applied, the friction element **52** becomes heated, and consequently the cooling liquid adjacent the inner surface of the element also becomes heated and becomes lighter. In view of the fact that the baffle **48** is inclined as shown in conical shape, it will be apparent that the heated liquid, being lighter, will tend to move toward the central portion of the mechanism along the left side of the baffle, while at the same time the liquid on the right side of the baffle, being cooler and heavier, will be thrown outward by centrifugal force to replace the heated liquid adjacent the inner surface of the friction element. Consequently, the liquid will circulate due to the well known thermo-syphon action, and this circulation will be continuous as long as the liquid on one side of the baffle is of a different temperature from that on the other side. The structure may well be compared to a water tube boiler, wherein means are provided for preventing the flow of cooled liquid in one direction from interfering with the flow of heated liquid or hotter liquid in the opposite direction, as occurs when boiling water in an ordinary open kettle. A properly placed baffle inserted in such a kettle immediately changes the condition of operation and results in a controlled flow of cooler liquid in one direction and hotter liquid in the opposite direction, thus resulting in much more efficient operation.

The structure shown is of particular value when utilized on the vertical shaft of a helicopter rotor to stop the rotor when the vehicle alights to take on passengers, a procedure which is considered necessary in some cases. In this event, the top of the mechanism would be at the left of FIG. 4, and it is for this reason that the relief valve mechanism **51** is shown connected with the reservoir near the axis and at the highest point thereof with the shaft in the vertical position. With this arrangement of the relief valve mechanism, it will be apparent that when the cooling liquid in the mechanism has once been expanded at the maximum temperature at which the mechanism operates, assuming that the mechanism was originally filled with the cooling liquid, that thereafter nothing can escape from the valve except steam or vapor, thus effectively preventing the unnecessary loss of cooling liquid. This arrangement also facilitates the filling of the mechanism to any desired level in the event liquid is lost by evaporation or leakage. It will be noted that the friction element may be sealed at its right and left ends in the same general manner as shown in FIG. 1. This structure may of course be utilized on a horizontal shaft of a helicopter rotor transmission if desired.

With regard to the metal utilized to form the rotor member of FIG. 4, it will be understood that light metals such as aluminum and magnesium and alloys thereof may be utilized to good advantage in the same manner as was the case in connection with FIG. 1 in order to provide a high heat storage capacity as well as good heat dissipating characteristics. In both structures, the radial depth of the liquid in the mechanism is sufficient to provide an appreciable pressure at the region adjacent the cylindrical friction element, thus raising the boiling point of the liquid appreciably in order to permit the mechanism to operate at a higher temperature without dissipating cooling liquid in the form of steam or vapor.

With regard to the structures shown in FIGS. 1 and 4, it should be added that in the event the wheel or drum is not completely filled with liquid, the wheel may have a marked shock absorbing action on the vehicle to which the wheel is applied, this being due to the fact that the liquid in the wheel has inertia and will tend to absorb energy imparted to the wheel due to road shock. This action also tends to agitate the liquid and improve the heat transfer characteristics from the liquid to the metal of which the mechanism is formed. The invention also, as heretofore described, provides a novel method of initially preparing a wheel or drum of this type for installation on a vheicle by completely filling the mechanism with liquid, placing the mechanism in an oven at a predetermined temperature to expand the liquid, and thereafter cooling the mechanism to form a vacuum therein. The invention is also applicable to use in friction clutches.

As utilized herein, the term "high thermal conductivity metals" is intended to mean copper, silver and alloys thereof. The term "relatively high conductivity metals" is intended to mean aluminum, magnesium, and alloys thereof.

While the use of the "high thermal conductivity metals" is preferred for the friction elements **21***a* and **52** it will be understood that in certain types of uses of the invention, the friction elements may be formed of the "relatively high conductivity metals" or other suitable metals if desired.

Although the invention has been illustrated and described herein with considerable particularity, it is understood that the invention is not to be considered as limited thereto, but may be embodied in other forms as may well suggest themselves to those skilled in the art. Reference, will therefore, be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A liquid-cooled rotatable brake drum for a friction brake including a hub, a closed chamber of appreciable radial depth formed in said drum substantially concentric with the axis of the drum and adapted to contain a cooling liquid therein, said chamber being enclosed by spaced apart walls, a continuous partition in the chamber connected with and supported by a wall of said chamber and extending around said chamber, the opposite sides of the partition being spaced from the adjacent chamber walls and the inner and outer edges of said partition being radially spaced apart and spaced from the chamber walls adjacent thereto to provide passages for cooling liquid therebetween, a friction surface formed on the outside of one chamber wall and spaced radially outward from the innermost portion of the chamber, one side of the partition having a surface substantially in alignment with the inner surface of said one chamber wall directly opposite said friction surface, whereby said partition serves to direct the flow of heated liquid from said inner surface toward the innermost portion of said chamber along one side of the partition and serves to direct the flow of cooled liquid toward the outermost portion of said chamber along the other side of said partition, and enclosed radial air passages formed along the surface portion of said drum, said passages being open at their inner ends adjacent said hub and open at their outer ends adjacent the periphery of said drum.

2. A liquid-cooled brake drum for a friction brake including a drum member having a hub, axially spaced walls extending radially outward from the hub, a cylindrical metal friction element drivably secured to the peripheral portion of at least one of said walls and slidably engaging the peripheral portion of the other of said walls, said hub, walls and element forming a closed annular chamber for cooling liquid, and a continuous substantially conical partition provided in said chamber and connected to and supported by said drum member, the inner periphery of the partition being spaced outwardly from the outer surface of said hub and being adjacent to but spaced from the inner surface of one of said walls and the outer periphery of said partition being adjacent to but spaced inwardly from the inner surface of said friction element and being adjacent to but spaced from the inner surface of the other of said walls.

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