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(54) Benævnelse: **MOBILE CALIBRATING APPARATUS FOR A TEST STAND FOR BRAKES**

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Mobile calibrating device for a brake test stand

The present invention relates to a mobile calibrating device for calibrating brake test stands for wheel-driven motor vehicles, such as motorbikes, cars, trucks or other wheel-driven and brakeable vehicles.

Brake test stands are systems in which the effects of the vehicle brake of a motor vehicle are determined in the course of brake tests during routine technical inspection of the vehicles, and which for that purpose directly indicate and/or record the measured braking force individually for each wheel. Usually, and in the meaning of the invention, a brake test stand comprises two brake test rollers mounted parallel at a distance Ar, between which a wheel of a motor vehicle can be received and its braking force recorded. The calibrating device serves to record the braking force recorded by the brake test stand under defined conditions regardless of the evaluation system, to allow an accuracy check or calibration of the brake test stand to be performed.

Usually, a brake test stand facility comprises at least two parallel-arranged brake test stands, to allow the braking effect of each wheel of a vehicle axle to be recorded parallel and individually. It is nevertheless also possible to calibrate a brake test stand which is designed for jointly determining the overall braking effect of both wheels of a vehicle axle, wherein for design reasons the two wheels act on two linked pairs of brake test rollers.

PRIOR ART

Various calibrating devices for calibrating a test stand for vehicle brakes are known from the prior art. Calibrating devices used for calibrating brake test stands are known from for example DE 100 53 513 A1 and DE 41 35 766 C1.

In addition, generic calibrating devices are known from DE 38 05 724 C1, DE 103 05 346 A1, DE 103 26 116 A1, DE 10 2011 088 424 A1, US 2012/0297858 A1 and DE 20 2016 005 174 U1.

DE 41 35 766 C1 describes a mobile calibration unit for a vehicle brake stand. In this connection, the calibration unit integrated into a production vehicle comprises, in addition to a standard brake caliper, a measuring brake caliper that acts on the brake disk of a vehicle wheel. The measuring brake caliper is on one side mounted swivelably about an axle on a base plate firmly connected to the wheel carrier of the production vehicle, and on the other side supported by a torque support, designed as a tension rod, on the wheel carrier of the production vehicle. The torque support has a force measuring arrangement with strain gauge to record a force-dependent elongation of the torque support.

A calibration unit of the same generic type is described in EP 1 202 037 A1. In this unit, forces acting on a measuring brake caliper are transmitted via two arm-like holding elements and two measurement supports firmly connected to a rotationally fixed axle of a measuring wheel, wherein the measurement supports carry the measuring brake caliper on the rotationally fixed axle. Measuring strip arrangements are provided for recording force-dependent shape changes of the measurement supports.

A disadvantage of the calibrating devices known from the prior art is that they are expensive to transport and assemble and do not permit measurement of very high braking forces up to the measurement limits of the brake test stand. Furthermore, the previously known calibrating devices contain a large number of error sources and are relatively expensive and complex to operate.

Deutsche Akkreditierungsstelle GmbH (DAkkS) is the national accreditation body of the Federal Republic of Germany, headquartered in Berlin. This body has in the past criticized that calibration measurements in the field of motor vehicle testing in particular are unsatisfactory and that the calibrating devices and methods already employed do not deliver reliable values in certain cases. There is thus an urgent need to increase their accuracy, operability and insusceptibility to miscalibration. DAkkS has issued a guideline for application, characteristics and testing of brake test stands (brake test stand guideline), applicable with effect from 01.10.2011 for new brake test stands being taken into service, and with effect from 01.01.2020 for all brake test stands. It is provided that the maximum determined braking force below a switch-off value of the brake test stand is measured, and the determined braking force is compared with a test measurement force obtained using a reproducible measurement procedure for calibration. Testing of the brake test stand must be performed before the test stand is first taken into service at the installation location, before being taken into service at changed installation locations, and thereafter at intervals of no more than two years.

The error limits for indication and recording of braking forces are +/- 2 % of the current measured value in test stands up to a nominal maximum braking force of 8 kN in the measurement range of 0 – 2000 N +/- 40 N and above, and +/- 2 % of the current measured value in test stands above a nominal maximum braking force of 8 kN in the measurement range of 0 – 5000 N +/- 100 N and above.

For compliance with the brake test stand guideline and for checking and setting of brake test stands, a calibrating device is used that firstly can analyze and record the functioning of the brake test stand by measurement means and secondly can be used for calibration, i.e. adjustment of the brake test stand.

The problem of the prior art is that the previously used calibrating devices are inaccurate in particular at measurement range limits, incorrect operation can occur, and application, transport and use involve heavy expense.

The object of the invention is therefore to propose a calibrating device that can resolve the problems of the prior art as stated above.

The above object is achieved by a calibrating device according to the independent claim. Advantageous embodiments are the subject matter of the sub-claims.

DISCLOSURE OF THE INVENTION

The subject matter of the invention is a calibrating device for a brake test stand, wherein the brake test stand has two brake test rollers mounted parallel at a distance Ar.

It is proposed that the calibrating device has at least one measuring wheel interacting with the brake test rollers, a braking device for controllable braking of the measuring wheel, a torque arm by which the braking device is supported in a support point for transmission of a counterforce occurring during braking of the measuring wheel, at least one force measuring sensor designed to determine the counterforce effective at the support point, and a calibration evaluation device linked to the force measuring sensor for processing and/or displaying measured values recorded by the force measuring sensor.

In accordance with the invention, the braking device presses on the force measuring sensor via the torque arm relative to a floor surface. In this embodiment in accordance with the invention, the torque occurring during braking of the measuring wheel leads to an increase in the measured values determined by the force measuring sensor, wherein the force measuring sensor determines a compressive force of the torque arm onto the floor surface. Part of the braking force is here transmitted to the floor and hence the contact pressure force of the measuring wheel onto the brake test roller during braking is reduced.

Alternatively, a ramp is provided in accordance with the invention that receives a ballast weight, in particular the weight of a vehicle, and presses at its one end on a rotary axle of the measuring wheel, and the torque arm is attached underneath the ramp and presses against the underside of the ramp via the force measuring sensor. As a result, support on the floor side is not necessary, and the torque and hence the weight force is transmitted not into the floor, but back into the ramp. Due to this support of the torque arm, no weight force is lost during braking, and on the contrary the contact pressure of the calibrating device is even increased, and acts as before on the rotary axle. The measurement setup can be compact in design, and no space is needed beyond the ramp for supporting the torque arm. The contact pressure force of the measuring wheel is increased and the design is smaller.

As soon as the braking device is activated, the force exerted by the torque arm onto the force measuring sensor changes, wherein the change in the counterforce is a measure for the size of the braking force. Accordingly, the supporting force is determined directly or indirectly by the force measuring sensor. The force measuring sensor is configured to measure directly or indirectly the counterforce acting on the torque arm during support. To do so, a load cell, a strain gauge, a hydraulic sensor, a piezoelectric or magnetostrictive sensor, a torsion sensor or a comparable torque or force measuring sensor, for example, can be used at the support point of the torque arm. Depending on the configuration of the calibrating device, the torque acting on the torque arm during braking of the measuring wheel can both lead to an increase in the force registered by the force measuring sensor and also effect a reduction of a force applied for example by a ballast weight and registered by the force measuring sensor. The measured values recorded, and if applicable processed, by the calibrating device therefore correspond to the actual braking forces generated by the braking device and can be used for calibration of the measured values for the braking force determined by the brake test stand. By using the torque arm, a braking force can be determined largely independently of the contact pressure force of the measuring wheel onto the brake test stand, so that the force measuring sensor is subjected to a load proportional to the braking force only during brake operation. Compared with conventional systems, which use for example a biased torque sensor, there is practically no offset in the determination of the braking force, so that no complex and larger structure is required to keep a contact pressure force away from the braking force sensor.

The measuring wheel is in particular designed as a double measuring wheel, wherein the measuring wheels are connected to one another via an axle and the braking device acts on the axle. The distance between the two measuring wheels is advantageously dimensioned such that they contact the outer axial areas of the brake test rollers, as they are as a rule only slightly worn. It is conceivable to design the measuring wheel also as a cylindrical measuring roller in order to obtain a large contact surface with the brake test rollers.

It is conceivable for the torque arm to be arranged between the braking device and the measuring wheel(s) on or in a measuring wheel axle. A torsion or torque sensor can be arranged in the measuring wheel axle and can record the torques occurring during braking, to permit calculation of the braking force therefrom. The braking device can here be permanently fastened to an outer fastening structure. For exact braking force calculation, it would be advantageous in this case that the axle section of the measuring wheel(s) provided with the torsion or torque sensor remains free of weight force, such that a loading weight acting on the measuring wheels is not transmitted via the torsion or torque sensor. It would be conceivable to arrange the braking device on one side on an axle end area of a double measuring wheel arrangement and not between two measuring wheels, and to measure the torque in this axle end area between the braking device and the first measuring wheel.

The braking device is used to exert a braking effect on the measuring wheel. In an advantageous development, the braking device can be a hydraulic disc brake with settable braking force which is fastened rotatably to an axle of the measuring wheel and acts on the rotary axle of the measuring wheel. It has been shown that disk brakes can exert a high braking force; they are installed on most vehicle models. The braking force is easy to set, for example using a variable hydraulic pressure in the brake cylinders. An electric-powered hydraulic pump can be used to do so. The braking force used can be recorded indirectly using a current consumption by the hydraulic pump or using a hydraulic pressure sensor. A brake test stand can therefore be calibrated with differing braking forces, wherein the test sequence can be automated and different braking forces can be applied in each case. Alternatively to a hydraulic braking force control, a pneumatic or an electromechanical braking force control for the braking device can also be used.

Proceeding from this, a multi-disk brake can be advantageously used as a specific form of a disk brake. Multi-disk brakes are also referred to as full disk brakes, since the entire surface of the brake disk can be used for deceleration. Several inner and outer plates preferably running in an oil bath are pressed axially against one another, thereby creating a braking effect. It can be used in particular at low rotation speeds with high braking torque.

In an advantageous development, the calibrating device can have a ramp for receiving a ballast weight, in particular a vehicle, wherein the ramp presses at its one end on a rotary axle of the measuring wheel. To achieve the most accurate calibration possible, any slippage between the measuring wheel and the brake test rollers must be prevented wherever possible. This can be achieved by a sufficiently high weight force Fa acting on the ramp. This weight force can be expediently applied by a vehicle which stands with one or even both axles on the ramp and presses the measuring wheel onto the brake test rollers. The other end of the ramp is supported by the floor. The floor-side support of the ramp is preferably achieved relative to the axle of the measuring wheel opposite the support point of the torque arm. As a result, the weight applied by the ramp is transmitted via the floor-side support of the ramp and the measuring wheel, such that the torque arm is not subjected to any load therefrom. When driving onto the ramp, the vehicle is as a rule skewed, such that the wheel contacting the ramp can apply considerably more than 25% of the entire vehicle weight as a weight force onto the measuring wheel to increase a contact pressure force onto the brake test rollers. Due to the increased weight force onto the measuring wheel, higher braking forces can be achieved before any slippage occurs between the measuring wheel and the brake test rollers.

Particularly advantageously, the ramp can be driven on by a wheel of the vehicle to exactly onto or past the rotary axle of the measuring wheel, wherein a floor-side end of the ramp is pressable against an underbody of the vehicle. If the vehicle wheel is exactly above the rotary axle, at least 25% of the vehicle weight is transmitted onto the rotary axle. Since the load on the second wheel of a two-wheeled vehicle axle is reduced, between 25% and 50% of the vehicle weight can act on the rotary axle. The second front wheel attached to the opposite end of the axle is spatially deeper, i.e. directly on the opposite drive roller pair of the brake test stand, and the load on it is reduced. The wheel on the ramp of the calibrating device is therefore subjected to further loading and hence increases the maximum achievable braking force until slippage. In this position, therefore, the adjacent axle wheel of the vehicle rests on the parallel brake test stand for the second wheel of the wheel axle, so that a safety mechanism of the brake test stand is overridden and a regular brake test is simulated. The safety mechanism can be designed for example as sensing rollers that do not enable operation of the brake test stand until the wheel makes contact, wherein they can be pressed downwards on both sides in the aforementioned wheel position of the load vehicle. As a result, only the calibrating device is inserted between a vehicle wheel and a roller pair of the test stand. If the wheel of the vehicle is driven over the ramp, the floor-side end of the ramp tilts upwards and can press against the underbody of the vehicle. The ramp therefore absorbs the vehicle weight at two points, so that an even higher weight force can act on the rotary axle. In this case, contact by a vehicle wheel could be simulated at the adjacent roller pair of the brake test stand, i.e. a dummy wheel or the like could be placed underneath to override a safety mechanism. When the rotary axle is driven on or over by the vehicle wheel, a very high weight force of up to 50% of the vehicle weight can be exerted onto the measuring wheel, so that correspondingly high braking forces can be measured without slipping through.

In an advantageous development, a lever section can be fastened rigidly, in particular foldably or detachably, to the ramp such that the lever section and the ramp form a contact pressure rocker tiltable about the rotary axle of the measuring wheel. The lever section forms in a manner of speaking an extension of the ramp beyond the rotary axle and permits, by a subjecting the lever section to a lever force in the floor direction, the rotary axle and hence the measuring wheel to be subjected to a load in addition to the weight force applied by the ballast weight. The lever section can in particular be considerably longer than a length Hl of the ramp, so that even a load applied to the lever section by one person can lead to a marked increase in the contact pressure force on the measuring wheel. The contact pressure force acting on the measuring wheel can thus be increased several times over when compared to a contact pressure force acting exclusively via the ramp. Thanks to a foldable or detachable fastening of the lever section to the ramp, the contact pressure rocker can be folded up or dismantled into compact dimensions for transport purposes. Advantageously, the length HG of the lever section is variable, for example by a telescopic extendability or by a multiple folding capability of the lever section.

In an advantageous development of the previously described embodiment, a floor contact sensor can be arranged at that end of the ramp on the floor side which is designed to record any lifting of the support of the ramp on the floor side. As a result, it can be determined whether the aforementioned loading of the lever section in the floor direction is sufficiently large or - if lifting has not yet taken place - should be increased even further.

In an advantageous development, a ballast weight can be provided that presses on the force measuring sensor relative to a floor surface, wherein the torque arm presses on the ballast weight against a weight force exerted by the ballast weight and recorded by the force measuring sensor, wherein the counterforce occurring during braking of the measuring wheel leads to reduction in the load on the force measuring sensor, and wherein the counterforce is determined on the basis of a resultant reduction of the weight force recorded by the force measuring sensor. The counterforce occurring during braking of the measuring wheel is thus determined in the form of a differential measurement, wherein the braking force can be expediently determined by difference calculation between the weight forces when the measuring wheel is braked and unbraked.

In an advantageous development of the previously described embodiments, the ballast weight can be a motor vehicle. It is conceivable here that the measuring wheel can be formed by a vehicle wheel, and that the braking device acts on the vehicle wheel, in particular the braking device is provided by the vehicle brake. The support point at which the force measuring sensor records the counterforce can be formed here by another vehicle wheel.

In an advantageous development of the embodiment, in which a ramp is provided to receive a ballast weight, the torque arm can be formed by the ramp, wherein the ramp presses on the force measuring sensor with its other free end having the support point relative to a floor surface, or the force measuring sensor presses between the end of the ramp and an underbody of the vehicle if the latter has driven onto the ramp onto or past the rotary axle. The ramp can thus act as a torque arm, and the force measuring sensor can record the weight force change acting on the ramp during braking, or a compressive force with which the ramp presses against the underbody of the vehicle when the vehicle wheel drives past the rotary axle of the measuring wheel during braking.

A first guide roller mounted parallel to the measuring wheel can preferably be arranged on the ramp and forms, together with the measuring wheel or with a second guide roller mounted parallel to the measuring wheel and drive-linked to the measuring wheel, a receptacle for a vehicle wheel situated between the support point and the rotary axle, wherein the braking device is a braking device of the vehicle acting on the vehicle wheel. The braking device of the vehicle thus indirectly brakes the brake test rollers of the brake test stand, wherein the mass of the vehicle acting on the ramp prevents the calibrating device from springing out of the test stand. If for example the vehicle is located with its front wheels in the receptacle provided at the ramp, while the rear wheels of the vehicle press directly on the floor surface, the load on the rear vehicle wheels is reduced during braking of the front vehicle wheels located in the calibrating device, and at the same time the front vehicle wheels are subjected to an additional load in a corresponding degree. This change in the load conditions can be detected by the force measuring sensor.

In an advantageous development of the embodiment described above, the second guide roller can be linked to the measuring wheel by a transmission, in particular a chain gear or belt transmission, which transmits a given drive speed of the measuring wheel into a higher output speed of the second guide roller. By this transmission, the braking forces to be applied by the braking device of the vehicle are relatively small, so that the risk of any slippage occurring between the vehicle wheel and the second guide roller is reduced, thereby increasing the accuracy of the calibration.

In an advantageous development, the diameter Dmr of the measuring wheel can be greater than the distance Ar between the brake test rollers and less than or equal to 300% of the distance Ar, in particular less than or equal to 200% of the distance Ar, preferably 150% of the distance Ar between the brake test rollers, in order to achieve a wedge effect. The distance Ar is understood as the distance between the circumferential surfaces of the brake test rollers. The diameter of brake test rollers can thus usually be approx. 20 cm, and the distance between the axles can be 40 cm, so that the distance Ar is 20 cm. A measuring wheel can thus have a diameter of greater than 20 cm but no greater than 60 cm, preferably less than 40 cm, in particular 30 cm or 36 cm, to suppress any slippage effect by means of a wedge effect. The wedge effect significantly increases a transmissible force between the measuring wheel and a brake test roller.

It is thus possible to speak in a wider sense of an increase of the friction coefficient (the μ coefficient, friction coefficient, also referred to as coefficient of friction (formula symbol μ or f) is a dimensionless measure for the frictional force in relation to the contact pressure force between two bodies) between the measuring wheel and the brake test rollers, which can also be referred to as μ enhancement, so that any slippage falsifying the measurement result is practically ruled out.

This allows definition of an effective friction coefficient μ' that takes the wedge effect into account. It is calculated on the basis of the equation:

$$\mu' = \frac{\mu}{\sin\frac{\gamma}{2}}$$

where γ is the wedge angle, i.e. the angle between the tangents at the circumference of the measuring wheel in the contact points of the measuring wheel on the brake test rollers, and μ is the material-specific friction coefficient without exploitation of the wedge effect.

The following table shows a comparison of the increase of the friction coefficient resulting from exploitation of the wedge effect, expressed by the ratio μ'/μ of the friction coefficients, for two different measuring wheel diameters Dmr, wherein the diameter of the brake test rollers is 20 cm and their axle distance 40 cm:

Dmr [cm]	γ [deg]	μ'/μ
55	118	1.2
30	72	1.7

The measuring wheel diameter Dmr of 55 cm corresponds approximately to the diameter of a standard motor vehicle wheel, while the reduced measuring wheel diameter Dmr of 30 cm in comparison to it achieves an improvement of the friction coefficient of more than 40%.

A smaller measuring wheel diameter relative to a given test roller geometry is accordingly not only advantageous in respect of reduced slippage, but also prevents, due to the greater slope of the tangents at the circumference of the measuring wheel and to a higher downhill slope force resulting therefrom, the measuring wheel from riding up onto the brake test rollers at high braking forces and the calibrating device being pushed out of the brake test stand.

In an advantageous development, the measuring wheel can be a low- to non-compressible wheel, in particular a hard elastic wheel and/or a wheel with plastic cover, solid rubber cover or metal cover.

In an advantageous development, a length of the torque arm effective between a point of application of the braking device and the support point can be changeable to set the measurement range.

In an advantageous development, two measuring wheels can be arranged at end areas of a common rotary axle, in particular of a shaft forming the rotary axle. The braking device, in particular a disk braking device, can be arranged between the measuring wheels. As a result, the sensitive brake technology and possibly further measuring transducers and the force measuring sensor are safely protected between the measuring wheels. Both measuring wheels and the brake disk of a disk braking device can be arranged rotationally fixed on a common shaft.

In an advantageous development of the previous embodiment, the distance of the measuring wheels from one another can be selected such that each of the measuring wheels rests on a respective axial end area of the brake test rollers. In particular, the distance of the measuring wheels from one another can be greater than a width of an average motor vehicle wheel to be measured, so that the measuring wheels can rest on little-worn areas of the brake test rollers. As a result, force transmission to abraded areas of the brake test rollers can be avoided and hence any tendency to slippage can be additionally suppressed, allowing higher braking forces to be measured. Due to the resultant wide stance of the measuring device, with the two measuring wheels resting on the brake test rollers at the maximum distance apart, tilting and falsification of a measurement result is prevented.

In an advantageous development, the calibration evaluation device can be connected to a video camera provided for recording a video sequence of a braking force indicating device of the brake test stand, wherein the calibration evaluation device is configured for recording and replay of the video sequence and/or for determination of braking force measured values of the brake test stand from the video sequence, and for comparison of the braking force measured values with the measured values recorded by the force measuring sensor. A video-assisted recording of this type for the braking force measured values of the brake test stand is important in particular when the braking force measured values of the brake test stand cannot be electronically output (analog or digital) and/or the braking force indicating device is to be incorporated into the calibration process. The video sequence and the measured values of the force measuring sensor can in particular be synchronously recorded or can be subsequently synchronized. Divergences between the measured values recorded by the brake test stand and those recorded by the calibrating device can in this way be determined electronically.

In an advantageous development, the lever section and/or the torque arm can be of lightweight metal design, in particular of extruded aluminium sections, in order to provide a low weight and simple assembly capability of the calibrating device. For example, the contact pressure rocker can be designed for fitting together and hence easy assembly.

In an advantageous development, the calibrating device can consist of a set comprising a calibration evaluation device accommodated in an evaluation case and a measuring ramp comprising the measuring wheel(s), the braking device, the torque arm and the force measuring sensor, wherein electrical connections between the evaluation case and the measuring ramp are designed pluggable. A multi-part and compact design of the calibrating device is thus proposed. The measuring case can perform evaluation of the brake measurement, and the measuring ramp that of the mechanical and stressed parts such as measuring wheel, braking device and torque arm with force measuring sensor, which as a rule is a load cell but can also be another force or torque sensor suitable for directly or indirectly measuring the size of a contact pressure force of the torque arm at its support point, for example a strain gauge, a torsion sensor, a piezoelectric, magnetoelastic or optical sensor, a hydraulic pressure sensor or other types of torque transducer. The measuring ramp can be equipped with additional small rollers on the ramp side for easier transport. The two parts can be transported and assembled separately from one another and electrically connected to one another by a plug/coupler connection. An electrical connection is used to operate the force measuring sensor to record the torque force; one connection can control a hydraulic motor of an adjustable hydraulic disk brake and indirectly indicate a brake pressure using the consumption current; and one connection can read out a hydraulic pressure sensor, allowing the braking force to be deduced from the hydraulic pressure of the brake. The measuring ramp can comprise a hydraulic safety valve that can open in the event of overload in order to prevent any leakage or fracture of the hydraulic system due to excessive strain. In an emergency, the braking effect can be quickly ended in this way. Different braking forces are presettable using the hydraulic motor, so that the brake test stand can for example measure braking forces of different strength starting at 1 kN and in 1 kN intervals up to 6 kN or 8 kN, and calibration can be performed over the entire measurement range. The evaluation case can perform a test of this type in automated manner, wherein for example a wireless connection can be made, e.g. by means of WLAN, Bluetooth or similar with a handheld test indicating unit, allowing a tester to perform testing and calibration conveniently and at a safe distance with a mechanical connection. A test protocol record can be provided by means of a printer in the evaluation case. The multi-part structure permits a lightweight design, so that the calibrating device can be transported and used without any strain.

To determine the braking force, both the length of the torque arm and the radius or diameter *Dmr* of the measuring wheel and the measured supporting force of the torque arm are required. The length of the torque arm is here the radial distance from the rotary axle of the measuring wheel to the support point of the torque arm. The braking force *Fb* is obtained from the ratio of the length of the torque arm *lh* to the radius of the measuring wheel *Dmr/2*, scaled with the supporting force *Fh* acting on the torque arm, provided the former is aligned tangentially to the measuring wheel circumference.

$$Fb = \frac{2 \cdot lh}{Dmr} \cdot Fh$$

As a rule, the torque arm is formed by an L-shaped bracket, of which the short member length *h* starts at the rotary axle of the measuring wheel and the long member length *l* leads to the support point of the torque arm. In this case, the following vectorial-mathematical relationship results:

$$Fb = \cos(90\,° - \tan^{-1}\frac{l}{h}) * \frac{2 \cdot \sqrt[2]{l^2 + h^2}}{Dmr} * Fh$$

For a protocol record of the calibration, advantageously both the length of the torque arm *lh* or *l* and *h* and also the diameter of the measuring wheel(s) *Dmr* can be stored, alterably if necessary, in the calibration evaluation device and recorded for every measurement in a protocol.

The diameter *Dmr* of the measuring wheel is of crucial importance for the accuracy of the braking force recorded by the calibrating device and can shrink due to wear. A diameter reduction of for example 2 mm can thus cause a divergence in the measured braking force of more than 0.5%. Advantageously, a monitoring device for the measuring wheel diameter can be comprised in the calibrating device. The monitoring device can for example comprise a monitoring wheel or monitoring wheel segment arranged freely rotatable on the axle of the measuring wheel whose maximum radius is slightly less than a nominal radius of the measuring wheel. Freely rotatable means that a rotation of the measuring wheel axle can take place regardless of a rotation of the monitoring wheel or monitoring wheel segment. If the nominal radius of the measuring wheel diminishes, the monitoring wheel or monitoring wheel segment touches the brake test rollers and is at least slightly driven or set in rotation by them. The radius can preferably be 2 to 10 mm less than the measuring wheel. Advantageously, the monitoring wheel or monitoring wheel segment has an acentric center of gravity, so that it cannot rotate by itself relative to the measuring wheel axle due to the friction forces of a bearing. A movement sensor, e.g. a contactless measuring switch such as a Reed contact etc., can be provided which signals any critical shrinkage of the measuring wheel during a movement of the monitoring wheel or monitoring wheel segment, so that either the measuring radius can be compensated in the calibration evaluation device or the measuring wheel can be replaced. The radius of the monitoring wheel or monitoring wheel segment can be settable, so that if the diameter of the measuring wheel shrinks and the calibration evaluation device is readjusted, compensation of the monitoring wheel or monitoring wheel segment is possible.

Slippage of the measuring wheel occurs at a maximum measurement range limit when a braking force exceeds a weight force from the measuring wheel acting on the brake test rollers weighted with a static friction coefficient. In this case, a safety device of the brake test stand is triggered as a rule. To increase operating safety and to detect any slippage or tendency to slippage, a further freely rotatable slippage wheel, which consists of a compressible and soft material, e.g. a soft-elastic rubber or a pneumatic tire inflated with low pressure and with a diameter at least slightly greater than the measuring wheel, can advantageously be arranged on the axle of the measuring wheel. This slippage wheel continues to rotate, due to its larger diameter, even in the event of slippage, driven at least for a time by the brake test rollers, wherein a speed diverging from the measuring wheel results in the event of slippage. Since the slippage wheel is compressible, it absorbs practically none of the axle load, so that the contact pressure force of the measuring wheel is not affected. The speed of the slippage wheel can be determined using a slippage speed meter, and the speed of the measuring wheel using a measuring wheel speed meter, for example using a magnetic speed meter similar to a bicycle tachometer. The divergence of the two speeds creates a measure for any slippage occurring and can be evaluated by the calibration evaluation device. In the case of a tendency for slippage, the braking force can be reduced to prevent excessive slippage that could lead to an emergency shutdown of the brake test stand. Functioning of the safety device of the brake test stand can also be checked by a controlled slippage simulation.

The slippage wheel and / or the monitoring wheel or monitoring wheel segment can be advantageously arranged on an axle between two measuring wheels. If the relatively heavy measuring wheels are removed, the device can be transported using the slippage wheel or the monitoring wheel.

In addition, a method for operating an aforementioned calibrating device is proposed, comprising the steps:
Placing the calibrating device onto the brake test stand such that the at least one and preferably two measuring wheels are held between the brake test rollers,
Driving the at least one measuring wheel by means of the brake test rollers,
Operating the braking device for controllable braking of the at least one measuring

wheel, in particular with a settable braking force,
Determining the counterforce occurring during braking of the measuring wheel by means of the force measuring sensor,
Transmitting the measured values recorded by the force measuring sensor to the calibration evaluation device, and
Determining at least one braking force on the basis of the recorded measured values by means of the calibration evaluation device.

Advantageously, the brake test stand is calibrated on the basis of a comparison of at least one braking force determined by the calibration evaluation device with a corresponding braking force recorded by the brake test stand. A corresponding braking force is understood to be the braking force recorded by the brake test stand at the same point in time, i.e. with the same braking force acting on the measuring wheel, as the braking force determined by the calibrating device or its calibration evaluation device.

Advantageously, the calibrating device has a ramp for receiving a vehicle, wherein the ramp presses at its one end on a rotary axle of the measuring wheel, wherein for generating a contact pressure force Fa a vehicle is driven with one wheel onto the ramp. An operation is thus proposed of a calibrating device with the ramp subjected to load by a wheel of a motor vehicle in order to ensure a required slip-proof coupling of the measuring wheel to the brake test rollers.

Advantageously, a lever section is fastened rigidly, in particular foldably or detachably, to the ramp such that the lever section and the ramp form a contact pressure rocker tiltable about a rotary axle of the measuring wheel, wherein by applying a counterforce Fg onto the lever section of the contact pressure rocker free floating of the support of the ramp is achieved on the floor side and hence the measuring range is extended. Free floating achieves a maximizing effect on the strengthening of the contact pressure force, but the contact pressure force is also increased by an increase in a contact pressure force, i.e. without free floating of the ramp. The counterforce Fg can be introduced in different ways into the contact pressure rocker. One variant is to attach, at the time of calibration, an additional ballast weight to the end of the lever section, which results in an additional compressive force against the floor surface. Alternatively, it is also possible to have a tensile force acting against the floor surface. This may be brought about for example by a suction lifter or a magnetic pulling device. Compact suction lifters with suitable tensile force are available for example to aid the laying of concrete slabs. The required negative pressure can be generated by means of a vacuum injector from a compressed air supply routinely present at the testing location. If there is no direct floor contact due to the force acting on the lever section at both ends of the contact pressure rocker, the wheel weight of the vehicle and the lever force of the lever section acting on the floor side act on the measuring wheel such that even a relatively lightweight vehicle ensures a sufficiently high contact pressure of the measuring wheel against the brake test rollers, since the proportionate vehicle weight of a vehicle wheel acts on the rotary axle and provides a high frictional force.

Advantageously, the vehicle can be driven onto or past the rotary axle, wherein the ramp here presses against an underbody of the vehicle. This allows an increased weight force of the vehicle to act on the at least one measuring wheel, so that higher braking forces can be achieved without slippage. If the vehicle is positioned directly above the rotary axle of the measuring wheel or of the measuring wheels arranged in pairs next to one another and at a distance such that they run on the outer areas of the test rollers, then the adjacent axle wheel of the vehicle presses onto the adjacent test roller pair of the brake test stand due to the spring strut. As a result, a safety device that otherwise prevents movement of the test rollers is overridden, and a regular brake test is simulated at the brake test stand.

The individual features can of course be combined with one another, wherein further advantageous effects may be obtained that exceed the sum of the individual effects.

DRAWINGS

Further advantages are revealed by the present description of the drawings. The drawings show exemplary embodiments of the invention. The drawing, description and claims contain numerous features in combination. A person skilled in the art will expediently also consider the features individually and combine them into meaningful further combinations.

In the figures:

Fig. 1 shows schematically a first embodiment of a calibrating device for calibration of a brake test stand,

Fig. 2 shows schematically a perspective detailed view of the calibrating device of Fig. 1,

Fig. 3 shows schematically a second embodiment of a calibrating device for calibration of a brake test stand,

Fig. 4 shows schematically a third embodiment of a calibrating device for calibration of a brake test stand,

Fig. 5 shows schematically a fourth embodiment of a calibrating device for calibration of a brake test stand,

Fig. 6 shows schematically a fifth embodiment of a calibrating device for calibration of a brake test stand, and

Fig. 7 shows a circuit diagram of the electrical configuration of an embodiment of a calibrating device.

Identical or similar components are given the same reference signs in the figures.

Fig. 1 shows a brake test stand 50 comprising two brake test rollers 58 mounted rotatably and parallel at a distance Ar, between which a wheel of a motor vehicle can be held in order to record a braking force acting on the wheel. A braking force to be measured, which can be recorded by a deceleration effect to be measured when the braking test rollers 58 are driven, is passed on by speed or rotational acceleration sensors to a braking force evaluation device 54 and displayed on a braking force indicating device 56. This allows proper functioning of a motor vehicle brake to be checked.

To provide an exact and reproducible braking force record of the brake test stand 50, the brake test stand 50 is checked by means of a calibrating device 10 and calibrated as described in the following.

The calibrating device 10 comprises in accordance with a first embodiment a contact pressure rocker 30 having a ramp 28. The ramp 28 presses with its one end via an axle frame or the like on a rotary axle 34 designed as a shaft, wherein two measuring wheels 14 are fastened rotationally fixed on end areas of the shaft. The other end of the ramp 28 presses on a floor surface 52. Furthermore, the contact pressure rocker

10 comprises a torque arm 18, hinge-connected to the axle frame, shaft or ramp 28, which presses with its free end onto a force measuring sensor 20, for example a load cell, a strain gauge force transducer or similar torque transducers or force transducers. The force measuring sensor 20 is connected for signal evaluation to a calibration evaluation device 22 which can record a lever force applied by the torque arm 18 and determine therefrom a torque or braking force and output it using a calibration force indicating device 26.

The measuring wheels 14 are hard-elastic or non-elastic wheels that preferably contact outer edge areas of the brake test rollers 50 where the surface is not subjected to heavy loads and usually not worn down by motor vehicle wheels. The measuring wheels 14 each have, as shown in more detail in Fig. 2, a core of metal and a hard-elastic plastic or solid rubber cover with running surface, which advantageously has a profiled surface for improving contact with the brake test rollers 50 to prevent slippage. The diameter Dmr of the measuring wheels 14 is selected such that they sink relatively deeply between the two brake test rollers 58 in order to exploit a wedge effect. As a rule, the measuring wheels 14 are designed considerably smaller than a vehicle wheel, and the diameter can for example be 1.5 times the distance Ar between the brake test rollers 50.

A braking device 16, which is mechanically connected to the torque arm 18, acts on the shaft or on the measuring wheel 14.

In accordance with Fig. 2, the braking device 16 can be designed as a hydraulic disk brake with a brake disk 36 and a brake caliper 38. The brake disk 36 is fastened rotationally fixed on the shaft and positioned between the measuring wheels 14. The brake caliper 38 is fastened to the torque arm 18 or at least non-positively coupled thereto, so that the brake caliper 38 can press against the torque arm 18. The braking device 16 can be controlled for example by means of the calibration evaluation device 22.

If the braking device 16 is actuated, the non-positive coupling between the measuring wheels 14 and the brake test rollers 58 effects a deceleration of the brake test rollers 58, so that a braking force is indicated by the braking force indicating device 56 of the brake test stand 50.

Due to the braking force, and since the braking device 16 is rigidly coupled to the torque arm 18, a torque is applied to the torque arm 18, which exerts a force on the force measuring sensor 20 corresponding to the braking force.

For scaling or for measurement range extension, the length of the torque arm 18 can be settable to permit recording of the entire braking force measurement range and measurement of both low and very high braking forces.

The calibration evaluation device 22 can be connected to a video camera 24 provided for recording a video sequence of a braking force indicating device 56 of the brake test stand 50, wherein the calibration evaluation device 22 is configured for recording and replay of the video sequence and/or for determination of braking force measured values of the brake test stand 50 from the video sequence and for comparison of the braking force measured values with the force measured values recorded by the force measuring sensor 20, wherein the lever section 30 of the torque arm 18 is taken into account. The determination of the braking force measured values of the brake test stand 50 from the video sequence is possible with the aid of suitable image processing algorithms.

Alternatively or additionally, the braking force measured values determined by the braking force evaluation device 54 can also be transmitted electronically to the calibration evaluation device 22.

A comparison of the measured values recorded by the force measuring sensor 20, taking into account the effective lever section 30 of the torque arm 18, with the braking force determined by the braking force evaluation device 54 or indicated by the braking force indicating device 56, can be used to check or calibrate the accuracy of the brake test stand 50, which can thus also be calibrated.

To provide a high contact pressure force of the measuring wheels 14 on the brake test rollers 58, the ramp 28 is subjected to a high weight force Fa, for example by a wheel of a car or truck. The weight force is distributed onto the floor-side support 96 and the bearing at the rotary axle 34.

For a further increase in the contact pressure force, to permit an extension of the measurement range, a further weight force Fg can be generated at the lever section 30, for example by manually pressing down or clamping of the lever section 30 in the direction of the floor surface 52. This reduces the contact force of the floor-side support and hence increases the force transmitted to the rotary axle 34 until the floor-side support of the ramp 28 is lifted.

With an increase in the contact pressure force, riding up of the measuring wheels 14 onto the brake test rollers 58 can be prevented, allowing the braking force measurement range of the calibrating device 10 to be practically doubled, such that even end areas of the braking force measurement range can be calibrated. Preferably, the length of the lever section 30 is variable here, such that a low lever force Fg is sufficient to achieve free floating on the floor side of the floor-side end of the ramp 28. Furthermore, the distance of the lever section 30 to the force measuring sensor 20 for setting the rest position can be designed settable in order to set the torque occurring and hence furthermore achieve scaling of the braking force.

A floor contact sensor 32 can be advantageously provided that indicates free floating of the contact pressure rocker 12 on the floor side, such that adherence to a maximum contact pressure force can be signaled. If instead the contact pressure rocker 12 presses on an underbody of a vehicle 46, the floor contact sensor 32 or a contact sensor attached between the contact pressure rocker 12 and the vehicle underbody can signal a correct operating position of the contact pressure rocker 12.

Fig. 3 shows a calibrating device 110 in accordance with a second embodiment. The calibrating device 110 comprises a vehicle 46 with a body 44, front vehicle wheels 40 and rear vehicle wheels 42. A front vehicle wheel 40 assumes the function of the measuring wheel, while the body 44 acts as the torque arm. A rear vehicle wheel 42 stands on two force measuring sensors 20 which are connected to the calibration evaluation device 22. The force measuring sensors 20 measure a weight force applied by the weight of the vehicle 46 to the torque arm support point formed by the contact area of the rear vehicle wheel 42. The braking device is formed by the braking device of the vehicle (not shown) acting on the front vehicle wheel 44.

To perform a calibration, the brake test rollers 58 are driven and the front vehicle wheel 40 serving as the measuring wheel is decelerated by operating the braking device of the vehicle. Since the braking device presses on the body 44, a torque acts on the body 44, which leads to a reduction of the load on the rear vehicle wheel 42. The resultant reduction in the weight force is registered by the force measuring sensors 20, so that the braking force can be determined by difference calculation. Advantageously, the weight forces of the other three unbraked wheels 42 can be measured with load cells 20. It is furthermore advantageous when the front wheel 40 is a wide hard-rubber roller with a diameter reduced in comparison to the original wheel, in order to achieve a wedge effect and counteract any slippage.

Fig. 4 shows a calibrating device 210 in accordance with a third embodiment. The calibrating device 210 comprises a ramp 28 which on one side presses via a force measuring sensor 20 on a floor surface 52 and on the other side presses on a rotary axle 34 of a measuring wheel 14. The measuring wheel 14 is, in similar manner to the embodiment in accordance with Fig. 1, held between two brake test rollers 58 of a brake test stand.

At the ramp 28, a first guide roller is rotatably mounted at a distance from the measuring wheel 14 and forms together with the measuring wheel 14 a receptacle for a front vehicle wheel 40 of a vehicle 46. The part-section of the ramp 28 located between the rotary axle 34 and the support point on the force measuring sensor 20 forms a torque arm. A braking device acting on the front vehicle wheel 40 of the vehicle 46 serves as the braking device. The force measuring sensor 20 is in turn connected to a calibration evaluation device 22.

To perform a calibration, the driven brake test rollers 58 are decelerated indirectly by actuation of the braking device of the vehicle 46 via the front vehicle wheel 40 and via the measuring wheel 14 interacting with the front vehicle wheel 40 and the brake test rollers 58. This deceleration leads, as in the second embodiment in accordance with Fig. 3, to a reduction in the load on a rear vehicle wheel 42 of the vehicle 46, whereby the weight force acting on the front vehicle wheel 40 increases correspondingly. This change in the weight force is recorded by the force measuring sensor 20, so that the braking force can in turn be determined by means of difference calculation.

A calibrating device 310 in accordance with a fourth embodiment is shown in Fig. 5. The calibrating device 310 corresponds in its function principle and in its basic structure to the calibrating device 210 in Fig. 4, so that only the distinguishing features and the resultant advantages are explained in the following.

Compared with the calibrating device 210, the ramp 28 of the calibrating device 310 has a slightly greater structural length, wherein the first guide roller 60 is at a slightly greater distance from the measuring wheel 14, and between the first guide roller 60 and the measuring wheel 14 a second guide roller 62 is mounted which forms together with the first guide roller 60 a receptacle for a front vehicle wheel 40 of a vehicle 46. The second guide roller 62 is drive-linked to the measuring wheel 14 by a chain gear 64 acting as a transmission, wherein a given drive speed of the measuring wheel 14 translates into a higher output speed of the second guide roller 62.

In comparison with the calibrating device 210 (Fig. 4), the calibrating device 310 has a lower slope in the ramp 28, making it easier for the vehicle 46 to drive onto it. Furthermore, the braking forces to be applied by the braking device of the vehicle 46 are substantially lower due to transmission by the chain gear 64, considerably reducing the risk of the occurrence of slippage or riding up.

Fig. 6 shows a further embodiment 410 of a calibrating device. It substantially corresponds to the embodiment shown in Fig. 1, however the torque arm 18 does not press on a floor surface 52 but on an underside of the ramp 28. To achieve this, the force measuring sensor 20 is applied to the underside of the ramp 28, and records the torque which is exerted on the torque arm 18 upon actuation of the braking device 16, preferably a hydraulic disk brake with settable braking force. Since the torque arm 18 does not press on the floor surface 52, but on the ramp 28 of the contact pressure rocker 12, no weight force is transmitted outside the ramp 12 during braking, so that the force acting on the measuring wheel 14 is not reduced. The torque arm 18 can be designed compact here and have a length of 30cm to 50 cm. This allows higher braking forces to be exerted on the brake test stand 50. A vehicle 46 is driven with its front wheel 66 onto the ramp 28 such that the wheel 66 is vertically above the rotary axle 34 of the measuring wheel 14. This reduces the load on the axle-parallel second front wheel, which stands with the spring strut on the parallel and adjacent second brake test stand 50, so that a safety device provided therein is released and the brake test stand 50 is functional. In this position of the front wheel, the contact pressure rocker 12 is in a kinematically unstable position, wherein the end 96 of the ramp 28 is pressed against an underbody 94 of the vehicle 46 upon brake actuation. In this connection, support elements 68 can be slid underneath to achieve a kinematically defined position of the ramp 28. During braking, the ramp 28 presses against the vehicle, which has the further advantageous effect that the vehicle weight resting on the wheel 66 is now completely transmitted via the measuring wheel 14 and hence a higher contact pressure onto the brake test rollers 58 can be achieved. Since the load on the second front wheel is reduced, up to 50% of the vehicle weight can thus be transmitted onto the measuring wheel 14. If the wheel 66 of the vehicle 46 is positioned directly above the rotary axle 34, the vehicle rests both on the wheel 66 and on the end 96 of the ramp 28 losing ground contact, wherein the center of gravity of the vehicle 46 moves closer to the rotary axle 34, and proportionately more force is transmitted onto the measuring wheel 14 due to the additional support of the ramp 28 in its end area 96 close to the vehicle's center of gravity. Weight forces of > 50 % of the vehicle 46 can thus be exerted onto the measuring wheel 14, so that higher braking forces are still measurable.

If the front wheel 66 of the vehicle 46 is driven past the rotary axle 34, it is possible in this case to subject an axle-parallel and adjacent brake test stand 50 to loading by a dummy wheel or another device in order to bypass a safety function of the brake test stand 50.

The calibration evaluation device 22 is connected to the force measuring sensor 20 and to the braking device 16. It can set the braking force of the braking device 16, e.g. by an electrical parametrization of a hydraulic pump 74, and can determine the braking force indirectly, e.g. using a current consumption of the hydraulic pump 74 or a hydraulic pressure by a hydraulic pressure sensor 80. The calibration evaluation device 22 can thus preset a settable and controllable brake pressure of the braking device 16 and record the torque acting on the force measuring sensor 20. The recorded torque can be converted into a braking force by division by the length of the torque arm 18 in relation to the rotary axle 34. The braking force can be determined in several intervals up to the final measurement limit of the brake test stand 50, for example up to 6 kN or 8 kN, and checking and calibration of the brake test stand 50 can be performed therewith.

Fig. 7 shows a block diagram of the electrical configuration of an example 10, 110, 210, 310 or 410. The central component is the calibration evaluation device 22, which can for be designed as a portable set 102. This has a wireless interface 92, e.g. as WLAN, Bluetooth or similar air interface, for bidirectional communication with a calibration force indicating device 26 that can be operated as a hand-held test indicating unit 70, for example as a tablet, smartphone or notebook, by a testing person at a safe distance. For a protocol record, a test protocol unit 72, for example in the form of a printer as a further calibration force indicating device 26, can be connected as a portable set or externally to the calibration evaluation device 22.

The calibration evaluation device 22 is connected via one or more detachable plug/socket connections 98 to the electromechanical components of the measuring rocker 100. These components comprise a hydraulic motor 74 that can set a hydraulic pressure inside the hydraulic cylinder 76. This pressure is passed via hydraulic lines to hydraulic brake actuators 78, which exert a settable braking force on a brake disk 82 of the braking device 16. A hydraulic pressure sensor 80 monitors the hydraulic pressure, so that information on the brake pressure can be returned via the hydraulic pressure sensor 80 and via the motor current of the hydraulic pump 74 to the calibration evaluation device 22. Optionally, a hydraulic emergency valve can be provided that prevents overloading of the braking device 16.

The hydraulic motor 74 is controlled by a motor control device 86 until a required brake pressure is set. This can be determined using a motor current recorded by the motor control device 86 or using pressure information of the hydraulic pressure sensor 80 that can be output by a pressure measuring device 88. If the two values of motor current and hydraulic pressure diverge, a malfunction of the measuring ramp 100 may be diagnosed.

The force recorded by the force measuring sensor 20, which corresponds to a torque, is converted by a torque evaluation device 84 into a braking force when the length of the lever section 30 of the torque arm 18 is known. All data is processed by a computing unit 90 and can be internally or externally recorded, displayed or amended. Using an appropriate software application, values can be output and braking forces set by the test indicating unit 70.

The invention permits checking and calibration of a brake test stand by a compact mobile calibrating device which is easy to transport and quick to use. A contact pressure force of the measuring wheel(s) can be set within wide ranges, and a slippage-free and exact recording of the braking force by the calibrating device is possible. Many error sources in previous calibrating devices are avoided and an inexpensive and precise checking of brake test stands up to the maximum ranges for the recordable braking force is possible.

List of reference numerals

10, 110, 210, 310, 410	Calibrating device
12	Contact pressure rocker
14	Measuring wheel
16	Braking device
18	Torque arm
20	Force measuring sensor
22	Calibration evaluation device
24	Video camera
26	Calibration force indicating device
28	Ramp
30	Lever section
32	Floor contact sensor
34	Rotary axle
36	Brake disk
38	Brake caliper
40	Front vehicle wheel
42	Rear vehicle wheel
44	Body
46	Vehicle
50	Brake test stand
52	Floor surface
54	Braking force evaluation device
56	Braking force indicating device
58	Brake test roller
60	First guide roller
62	Second guide roller
64	Chain gear
66	Wheel of the load vehicle
68	Support element
70	Test indicating unit
72	Test protocol unit
74	Hydraulic pump
76	Hydraulic cylinder
78	Hydraulic brake actuator
80	Hydraulic pressure sensor
82	Brake disk
84	Torque evaluation device
86	Motor control device
88	Pressure measuring device
90	Computing unit
92	Wireless interface
94	Underbody of the vehicle
96	Floor-side end of the ramp
98	Detachable plug/socket connection
100	Measuring ramp
102	Evaluation case

Patentkrav

1. Kalibreringsanordning (10, 110, 210, 310, 410) til en bremseprøvestand (50), idet bremseprøvestanden (50) omfatter mindst et par bremseprøveruller (58), der er placeret parallelt med en afstand Ar, mindst et målehjul (14), der arbejder sammen med bremseprøverullerne (58), en bremseanordning (16) til styrbar bremsning af målehjulet (14), en drejningsmomentarm (18), hvormed bremseanordningen (16) er understøttet i et støttepunkt for at udlede en modsat rettet kraft, der opstår under bremsning af målehjulet (14), mindst en kraftmålesensor (20), der er beregnet til at bestemme den modsat rettede kraft, der er effektiv i støttepunktet, og en kalibreringsanalyseanordning (22), der er koblet til kraftmålesensoren (20), til behandling og/eller visning af målte værdier, der er registreret af kraftmålesensoren (20), **kendetegnet ved**, at bremseanordningen (16) er støttet på kraftmålesensoren (20) via drejningsmomentarmen (18) i forhold til en bundflade (52), eller at bremseanordningen (16) er støttet på kraftmålesensoren (20) via drejningsmomentarmen (18) i forhold til en underside på en rampe (28), idet rampen (28) er indrettet til at modtage en ballastvægt og med den ene ende støtter sig til en rotationsaksel (34) på målehjulet (14).

2. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til krav 1, **kendetegnet ved**, at bremseanordningen (16) er en hydraulisk skivebremse med justerbar bremsekraft, som er drejeligt fastgjort til en aksel på målehjulet (14) og virker på målehjulets (14) rotationsaksel (34).

3. Kalibreringsanordning (10, 210, 310, 410) i henhold til krav 1 eller 2, **kendetegnet ved** en rampe (28) til at modtage en ballastvægt, navnlig fra et køretøj (46), idet rampen (28) med den ene ende støtter sig til en rotationsaksel (34) på målehjulet (14), og hvor rampen (28) fortrinsvis kan køres over af et hjul (66) på køretøjet (46) op over rotationsakslen (34), idet en ende (96) af rampen (28) på undersiden kan understøttes af en undervogn (94) på køretøjet (46).

4. Kalibreringsanordning (10) i henhold til krav 3, **kendetegnet ved**, at en armsektion (30) er fastgjort fast, navnlig opklappeligt eller aftageligt, til rampen (28), således at armsektionen (30) og rampen (28) danner en trykbøjle (12), som kan vippes omkring målehjulets (14) rotationsaksel (34).

5. En kalibreringsanordning (10) i henhold til krav 3, **kendetegnet ved**, at der på enden (96) af rampen (28) på undersiden er placeret en bundkontaktsensor (32), som er beregnet til at registrere et løft af rampens (28) støtte på undersiden.

6. Kalibreringsanordning (110) i henhold til et af de forudgående krav, **kendetegnet ved** en ballastvægt, som støtter sig til kraftmålesensoren (20) i forhold til en bundflade (52), idet drejningsmomentarmen (18) støtter sig til ballastvægten på en sådan måde, at den modvirker en vægtkraft, der udøves af ballastvægten og registreres af kraftmålesensoren (20), og at den modkraft, der opstår under en bremsning af målehjulet, fører til en aflastning af kraftmålesensoren (20), idet modkraften bestemmes på grundlag af en herved fremkaldt reduktion af den vægtkraft, der registreres af kraftmålesensoren (20).

7. Kalibreringsanordning (110) i henhold til krav 3 eller 6, **kendetegnet ved**, at ballastvægten er et motorkøretøj (46), idet målehjulet fortrinsvis udgøres af et køretøjshjul (40), og idet bremseanordningen virker på køretøjshjulet (40).

8. Kalibreringsanordning (210, 310) i henhold til krav 3, **kendetegnet ved**, at drejningsmomentarmen er dannet af rampen (28), idet rampen (28) støtter sig til kraftmålesensoren (20) med sin anden frie ende, som viser støttepunktet, i forhold til en bundflade (52), eller at kraftmålesensoren (20) er placeret mellem enden af rampen (96) og en undervogn (94) på køretøjet (46), og at der på rampen (28) fortrinsvis er placeret en første styrerulle (60), der er placeret parallelt med målehjulet (14), og som sammen med målehjulet (14) eller en anden styrerulle (62), der er placeret parallelt med målehjulet (14) og koblet til målehjulets (14) drivkraft, danner en holder til et køretøjshjul (40), der ligger mellem støttepunktet og rotationsakslen, idet bremseanordningen er en bremseanordning på køretøjet (46), der virker på køretøjshjulet (40).

9. Kalibreringsanordning (310) i henhold til krav 8, **kendetegnet ved**, at den anden styrerulle (62) er koblet til målehjulet via en transmission, navnlig en kæde- eller remtransmission (64), som omsætter en given indgangshastighed for målehjulet (14) til en højere udgangshastighed for den anden styrerulle (62).

10. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at målehjulets (14) diameter Dmr er større end afstanden Ar mellem bremseprøverullerne (58) og mindre end eller lig med 300 % af afstanden Ar, navnlig mindre end eller lig med 200 % af afstanden Ar, fortrinsvis 150 % af afstanden Ar mellem bremseprøverullerne (58), for at fremkalde en kileeffekt.

11. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at målehjulet (14) er et hjul med lav eller uden kompressibilitet, navnlig et hårdelastisk hjul og/eller et hjul med plastkappe, massiv gummikappe eller metalkappe.

12. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at en længde af drejningsmomentarmen (18), der virker mellem et indgrebspunkt på bremseanordningen (16) og støttepunktet, kan ændres med henblik på indstilling af måleområdet.

13. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at to målehjul (14) er placeret i endeområder af en fælles rotationsaksel (34), navnlig en aksel, der danner rotationsakslen (34), og at bremseanordningen (16), navnlig en skivebremseanordning, navnlig er placeret mellem målehjulene (14).

14. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til krav 13, **kendetegnet ved**, at afstanden mellem målehjulene (14) er valgt således, at hvert af målehjulene (14) hviler mod et pågældende aksialt endeområde af bremseprøverullerne (58).

15. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at kalibreringsanalyseanordningen (22) er forbundet med et videokamera (24), der er beregnet til at optage en videosekvens på en bremsekraft-visningsanordning (56) på bremseprøvestanden (50), idet kalibreringsanalyseanordningen (22) er indrettet til at optage og gengive videosekvensen og/eller til at bestemme bremsekraftmåleværdierne for bremseprøvestanden (50) ud fra videosekvensen og til at sammenligne bremsekraftmåleværdierne med de målte værdier, der er registreret af kraftmålesensoren (20).

16. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at armsektionen (30) og/eller drejningsmomentarmen (18) er fremstillet i en letmetalkonstruktion, navnlig af ekstruderede profiler, for at give en lav vægt og en nem samling af kalibreringsanordningen (10, 110, 210, 310, 410).

17. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at kalibreringsanordningen (10, 110, 210, 310, 410) består af et sæt, der omfatter en kalibreringsanalyseanordning (22), som er placeret i en analysekuffert (102), og en målerampe (100), som består af målehjulet (14), bremseanordningen (16), drejningsmomentarmen (18) og kraftmålesensoren (20), idet de elektriske forbindelser mellem analysekufferten (102) og målerampen (100) er udført med stik.

18. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved** at omfatte en overvågningsanordning for målehjulets diameter, som fortrinsvis består af et overvågningshjul, der fortrinsvis kan rotere frit, og som er placeret på målehjulets aksel, eller et overvågningshjulsegment, hvis maksimale radius er en smule mindre end målehjulets nominelle radius.

19. Kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved**, at der på målehjulets aksel er placeret et rotationsfrit sliphjul, som er fremstillet af et kompressibelt, blødt materiale, og hvis diameter mindst er en smule større end målehjulets, idet sliphjulets og målehjulets omdrejningshastighed kan registreres uafhængigt af hinanden.

20. Fremgangsmåde for betjening af en kalibreringsanordning (10, 110, 210, 310, 410) i henhold til et af de ovenstående krav, **kendetegnet ved** følgende trin:

- Kalibreringsanordningen (10, 110, 210, 310, 410) placeres på bremseprøvestanden (50) på en sådan måde, at mindst ét målehjul (14) er anbragt mellem bremseprøverullerne (58)

- Målehjulet (14) drives ved hjælp af bremseprøverullerne (58)

- Betjening af bremseanordningen (16) for en styrbar bremsning af målehjulet (14), navnlig med en justerbar bremsekraft

- Bestemmelse af den modkraft, der opstår under bremsning af målehjulet (14), ved hjælp af kraftmålesensoren (20)

- Overførsel af de måleværdier, der er registreret af kraftmålesensoren (20), til kalibreringsanalyseanordningen (22)

- Bestemmelse af mindst én bremsekraft på grundlag af de registrerede måleværdier ved hjælp af kalibreringsanalyseanordningen (22).

21. Fremgangsmåde i henhold til krav 20, **kendetegnet ved**, at bremseprøvestanden (50) kalibreres eller justeres på grundlag af en sammenligning af mindst én bremsekraft bestemt af kalibreringsanalyseanordningen (22) med en tilsvarende bremsekraft, der er registreret af bremseprøvestanden (50).

22. Fremgangsmåde i henhold til krav 20 eller 21, **kendetegnet ved**, at kalibreringsanordningen (10, 110, 210, 310, 410) omfatter en rampe (28) til modtagelse af et køretøj (46), idet rampen (28) med sin ene ende støtter på en rotationsaksel (34) på målehjulet (14), idet et køretøj køres med et hjul op på rampen (28) for at generere en pressekraft Fa, og en momentkraft registreres af kraftmålesensoren (20), når målehjulet (14) bremses.

23. Fremgangsmåde i henhold til krav 22, **kendetegnet ved**, at en armsektion (30) er fastgjort fast, navnlig opklappeligt eller aftageligt, til rampen (28), således at armsektionen (30) og rampen (28) danner en trykbøjle (12), som kan vippes omkring målehjulets (14) rotationsaksel (34), og at der ved at påføre en modkraft Fg på armsektionen (30) af trykbøjlen (12) opnås et frit svævepunkt for rampens (28) støtte på undersiden og dermed en udvidelse af måleområdet.

24. Fremgangsmåde i henhold til krav 23, **kendetegnet ved**, at køretøjet køres op til eller over rotationsaksen (34), og at rampen (28) understøttes i forhold til undervognen (94) på køretøjet (46).