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A Review Paper On Disc Brake Caliper Hub

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Abstract - Reverse engineering is a process of analyzing existing components to obtain enough data to replicate design or knowledge of those parts. Data obtained during reverse engineering can be used to lower production costs, improve component properties, or replace components. In this project reverse engineering was used to obtain information from model of the motorcycle brake caliper brackets to redesign and improve that component of the motorcycle.First step of the process was to 3D scan the model. Then scan was transferred to creo software for redesign. From there all precise dimensions were defined and final improved models could be 3D printed. Using reverse engineering process on this component allowed us to manufacture new brake caliper brackets so that larger brake discs could be installed thus improving braking power of the motorcycle. In this way original front forks and brake callipers could be used thus eliminating need of upgrading those components and lowering overall cost of the process.

***Key Words*:** Reverse engineering, Disc, Caliper, 3D Printed, Creo software

1.INTRODUCTION

Reverse engineering, sometimes called back engineering, is a process in which software, machines, aircraft, architectural structures and other products are deconstructed to extract design information from them. Often, reverse engineering involves deconstructing individual components of larger products. The reverse engineering process enables you to determine how a part was designed so that youcan recreate it. Companies often use this approach when purchasing a replacement part from an original equipment manufacturer (OEM) is not an option.

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2. LITERATURE SURVEY

Hydraulic transmission brakes. RUBURY, J. M., Park Hall, Bradwell, Braintree, Essex. Oct. 6, 1930, No. 29937. [1] Hydraulic mechanism comprises a mechanically operated piston in a cylinder in communication with a liquid tank a second piston in a cylinder, and communicating with the first piston, a definite pressure non-return device in a duct between the spaces on each side of the second piston and a hydraulic device operating the brakes. The piston is adapted to be moved by the pedal to cover an inlet communicating with the liquid tank and moves the piston by means of a spring to force fluid to the brakes through pipes. At the moment when the brake shoes engage the drum the piston h is arranged to engage a stop l and any further movement of the pedal moves the piston d alone forcing liquid past the spring-pressed valve which recloses when liquid ceases to. flow. Wear of the' brake shoes is thus compensated.

Fluid-pressure brakes. HALL, F. H., Cleeve Cottage, Holford, near Bridgewater, Somerset. Sept. 2, 1931, No. 24622. [2] In brakes of the kind comprising a pair of shoes each applied to a drum by a hydraulic piston, the two pistons work in separate chambers or cylinders and a piston valve device whereby the quantity of liquid retained. in the cylinders is adjusted to maintain a constant clearance of the shoes from the drum to compensate for wear is provided in each cylinder inlet so that each shoe is separately adjusted. As shown, brake shoes pivoted at one end to an anchor plate are engaged at the other end by pistons respectively. The pistons work in cylinders separated by a partition and formed. in a single casting which is bolted at to the anchor plate and includes a part in which inlet plugs are screwed. The plugs carry a fitting for connection to the pipe line.

Raymond J. Norton, Washington, D. C., assignor to Bendix Brake Company, South Bend, Ind., a corporation of Illinois Application January 9, 1931, Serial No. 507,687 4 [3] This invention relates in general to automotive vehicle brakes and more particularly has reference to the mechanism for actuating the means for engaging the brake drum to retard rotation thereof. Brake mechanism of various constructions have been perfected. One type of brake having many desirable features and advantages over other types is that employing an internal expanding. braking element. Under certain conditions it has been found that brake construction of this type and also brake construction of other types has a tendency to grab or chatter when applied. That is, the lining carried by the braking element grabs the drum to lock the drum against rotation or successively grabs and releases the drum causing a chatter. These effects are disagreeable to the driver and reduce the efficiency of the braking system.

Niels Peter Valdemar Biniff, Copenhagen.Denmark Application October 20, 1930, Berial No. 489,990 In Denmark October 22, im I Claim (CL 139-72) [4] This invention refers to improvements in friction brakes particularly for rail vehicles such as tramway or railway vehicles and has for its object to provide a simple and effective arrangement 9 whereby the braking effect obtained by a number of braking devices is compensated without applying any substantial bending stress to the axle. According to the present invention a brake is provided having friction bodies acting on a brake disc mounted on an axle wherein the

friction bodies are carried one at each end of a lever arm, preferably right angled, the other end of said arms being connected with a connecting rod mechanism by means of which the lever arms are rotated to force the friction bodies against the said brake disc.

William Leicester Avery, Thorley, Bishop's Stratford, England Application November 2, 1932, Serial No. 640,886 In Great Britain November 12, 1931 [5] This invention relates to brakes for automobiles and aero plane landing wheels, and is applicable to brakes generally and also to clutches, and the term "brake" when used herein is to be given a correspondingly broad interpretation. The object of the present invention is to provide an ‘improved construction of brake which may be simply manipulated and. which will operate efficiently while at the same time being of an enclosed construction so as to be substantially dust- and dirt-proof. In carrying my invention into effect in one convenient mariner as for example in its application to braking mechanism for the landing wheels of an aero plane I form my improved brake with a central hub member a adapted to be secured to some fixed part of the structure by means of a torque ever or otherwise and dimensioned if necessary to enable the spindle of the landing wheel to pass therethrough.

V-TYPE BRAKE FOR MOTOR VEMCLE 2 Robert A. Poage, Panhandle, Tex., and Marlin Z.Poage, Tallahassee, Fla.Application June 27, 1935, Serial No. 28,738 Renewed November 11, 1936 [6] Surfaces are shoes, preferably being. lined or faced as at with usual friction lining, which is adapted to directly engage the V-shaped braking surface when applied, but which is normally spaced. It will be noted that the brake shoes are oppositely inclined. Mounting said brake shoes, are a suitable number of metallic arms, those for the oppositely inclined brake shoes, being reversed whereby they are disposed in pairs, said arms having
outwardly diverging portions carrying the brake shoes, and having inwardly converging portions at their opposite ends, terminating in fastening flanges, through which bolts or screws pass to fasten the arms to the spindle.

Ludger E. La Brie, South Bend, Ind., assignor to Bendix Brake Company, South Bend, Ind., a corporation of Illinois Original application April 23, 1931, Serial No. 532,265 Divided and this application May 31, 1935, Srial No. 24,388.[7] The Invention relates to brakes and is illustrated as embodied in a novel type of shiftable-anchorage automobile brake. One feature of the invention relates to arranging for fluid-pressure application a brake of the type having a pair of floating or individually shiftable shoes, i. e., arranged to shift individually from one anchor to another so that both shoes have self -energizing characteristics in both directions of drum rotation. Preferably there are two fluid-pressure operators adjacent the opposite ends of the shoes, and these operators in the form illustrated in themselves embody a number of important features of novelty. One important object relates to simplifying the wear adjustment of a brake of this type, by utilizing the brake applying cylinders as adjustable (1. e., expansible) anchors instead of attempting to adjust the shoes.

Joseph A. Forbes, Detroit, Mob., assignor to Kelsey-Hayes Wheel Company, Detroit, Mch., a corporation of Delaware Application July 21, 1941, Serial No. 403,435 I Claim.[8] The invention relates to brakes and refers more particularly to brakes for wheels and especially Aircraft, wheels. The invention has for one object to Provide a powerful brake which can be compactly arranged. The invention has for another object to provide a brake so constructed that the rotatable friction members may be fixedly secured to the wheel to avoid rattle and noise. The invention has for a further object to provide an improved brake in which the relatively axially movable friction members exert balanced or equal pressures when applying the brake. With these and other objects in view, the invention resides in the novel features of construction and combinations and arrangements of parts as more fully hereinafter set forth. The brake embodying my invention is particularly applicable to wheels fox aircraft and, more especially, airplanes. As illustrated, the wheel comprises the hub, the wheel body, and the tire carrying rim.

Homer T. Lambert,. St. -Joseph, Miek,-.asgignor to Lambert Brake, Corporatioir, St.i Joseph, Mich._ a corporation- of Michigan Application June- 29, 1944" 6 Claims. (Cl. 198-7-2) [9] This invention relates to disk brakes' of the self-energizing, or servo-actuated. type, and ignore especially to brakes of this character which are applicable to heavy duty service, such as for heavy industrial machinery, passenger and freight carrying vehicles, including. automobiles, trucks, buses, airplanes, and the like,. where heavy loads and relatively high speeds require brakes which are capable of' withstanding. severe service conditions. The primary object of this invention is to provide a self -energizing brake in Which the self energizing. or servo action is developed to an exceptionally high state With a minimum of-effort thereby permitting easy and efficient decollator or stopping of heavy loads, Another object of my invention is to Pico vide an improved disk brake embodying a novel and efficient arrangement of multiple disks by which the self-energization is Multiplied Without undue complication of the brake design.

Homer T. Lambert, St. Joseph, Mich., assignor to Lambert Brake Corporation, St. Joseph, Mich., a corporation of Michigan Application May 28, 1943, Serial No. 488,864 6 Claims. (Cl. 188-72) I [10] My invention relates to improvements in power transmission and absorption devices commonly known as clutches and brakes and the like, and particularly to the friction members of such devices, by means of which the power is transmitted or dissipated, as the case may be. In the case of brakes for use in conjunction with airplane wheels or with other rotating parts characterized by their relatively high speed and or severe loads, considerable heat is generated, with consequent expansion and warpage, and frequent rupture or breakage of the braking elements. This is especially prevalent in the so called disk brakes where the friction elements are of circular or disk form. Of course, the destructive cracking or breaking of the disks may, in some measure, be reduced by the proper selection of materials from which the brake elements are constructed.

Ellery R. Fltch, Elyria, Ohio, assignor to Bendix Westing house Automotive Air Brake Company, Elyria, Ohio, a corporation of Delaware Application August 23, 1943, Serial No. 499,683 1 2 Claims.[11] This invention. relates

primarily to fluid pressure control mechanism and more particularly to fluid pressure control mechanism for the brakes of an airplane. It has previously been proposed to provide, in connection with an airplane equipped with hydraulic' brakes of more or less conventional type, a separate or auxiliary fluid pressure supply such as compressed air for operating the brakes in the event of failure of the hydraulic system, the flow of fluid pressure from the emergency supply being controlled by means of a brake valve located, adjacent the operator. In systems of this type, and particularly in systems wherein different fluid mediums are utilized in different portions of the system, it Is necessary to provide means for preventing intermixing of the fluids.

Patented Apr. 1Z 1949 2.94669990 UNITED STATES PATENT. OFFICE 2,466,990 SINGLE DISK BRAKE Wade C. Johnson, Cuyahoga Falls, Harry A. [12] Trishman, Hudson, and Edgar H. Stratton, Cuyahoga Falls, Ohio, assignors of one-half to Wingfoot Corporation, Akron, Ohio, a corporation of Delaware, and one-half to The Adamson Machine Company, Akron, Ohio, a corporation of Ohio Application November This invention relates to the construction of brakes and, in particular, to a brake of the single disk type for heavy duty use, operated by annular fluid pressure bags. Hitherto, brakes of this type had a relatively short life and did not work entirely satisfactorily, unless they were made relatively large and heavy. It is the general object of the invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of improved brake constructions of the character indicated.

Orby Bryant, Rolla, Mo. Application August 17,1949, Serial No. 44,677 1 [13] This invention. relates, to brakes operated by a pressure, fluid, and has particular reference to a brake apparatus which embodies adjustable. de vices for trap determined quantities of Ing, pre pressure fluid in the cylinders of a. pressure applying Devajee having two pistons; individually acting on the shoe, of such, a brake, whereby a predetermined working, clearance may be obtained between said shoes and the brake drum to compensate for wear of the friction material with which,, the shoes. are, faced., An object.- of the, invention is to- provide a brake apparatus which embodies a pressure applying device including a pair of pistons acting individually on the respective brake shoes, and separate devices adjustable for trapping different predetermined quantities of pressure fluid behind the respective pistons, so that the same working clearance may be obtained between the shoes and the drum even though the facings of the respective shoes may wear unevenly.

John G. Maitin, South Bend, 4nd., assignor to Bendix Aviation Corporation,.South-Beimd"-I[nd., a corporation'df3D6Iawar_e ry -Application4anua _23, 1946, Sefiir.Vo. 42,919 6.Cloiims. (CI-60-54-A A [14] This invention-,relates to adjustors for hydraulically actuated brakes and more particularly is concerned with hydraulic brake adjustors adapted to provide automatically a proper clearance in released position between rotatable and: non-rotatable braking surfaces. In as much as the hydraulic brake adjustor herein proposed and described is not 1ntended to compensate for or in any way, be controlled by temperature variations in the operating parts, it will be appreciated that it is primarily Applicable to and Intended. for. disc brakes rather than drum type brakes. In drum brakes, expansion of the brake drum due to temperature increases can result in locking the brakes, if there is an automatic adjustment which causes the shoes to automatically change their released position whenever movement beyond a predetermined distance is required to . obtain a full-brake application. If the shoes are-thus over adjusted,. subsequent cooling of the drum will lock the brakes.

Maurice Odile Dubois and Bernard Maurice Dubois, Soisy-sur-Montmorency, France Application February 26, 1947, Serial No. 731,154 In France November 28, 1945 Section 1, Public Law 690, August 8, 1946 Patent expires November 28, 1965 2 Claims. (Cl. 60-54.5)[15] In installations for the remote control, by means of a fluid which is incompressible or slightly compressible, such as oil for example, of any controlled device or mechanism (braking device clutch mechanism, tool, etc.) a delicate problem is set by the return to the inoperative position of said controlled mechanism when the pressure which has acted on it stops since it is important that between the inoperative and the operative positions there should be a predetermined margin, i. e., a given play, or a certain travel of the members which will hereinafter be called "return travel." It is advantageous for numerous reasons, some of which are of capital importance and involve safety requirements, that this return travel shall be known and preferably be constant. In the operative position, the controlled- member or members generally abut (brake shoes against brake drums, clutch discs against conjugated discs, tool against workpiece, etc.).

Joseph Warwick Kinchin, Lowsonford, near Lapworth England, assignor to Girling Limited, Birmingliam" England, a British company Application August 19, 1952, Serial No. 305,154 Claims priority, application Great Britain August 21, 1951 11 Claims. (Cl. 188-152) [16] This invention relates to improvements in disc brakes for road and other vehicles of the type in which opposed friction pads are adapted to be urged into engagement with opposite faces of a rotating disc at one or more points, the remainder of the disc being left open for cooling. The pads are mounted in the open inner ends of opposed axially aligned hydraulic cylinders in each of which works a piston engaging and actuating the pad, liquid under pressure being supplied simultaneously from a master cylinder to the liquid spaces in the brake cylinders between the pistons and the closed outer ends of the cylinders so that the pads are urged with equal force into engagement with the disc.

Thayer, Ken. "How Does Reverse Engineering Work?". *globalspec*. IEEE Global Spec. Retrieved 26 February 2018.[17] China's new Shenyang J-11 fighter jet bears a striking resemblance to the Russian Sukhoi Su-27 “Flanker” multirole fighter. Initially, China’s jet was an authorized copy of the Russian fighter; however, China wanted to produce it with local manufacturing technology. Chinese engineers used a method called reverse engineering in order to achieve this task, and now the Shenyang J-11 is headed for the skies of southern China. Reverse engineering is a process that examines an existing product to determine detailed information and specifications in order to learn how it was made and how it works. For mechanical assemblies, this

typically involves disassembly and then analyzing, measuring and documenting the parts. Reverse engineering is not limited to mechanical components or assemblies.

CN115371586A • 2022-11-22 • JIANGSU PROVINCE XUZHOU TECHNICIAN INST [18]Reverse engineering is a process of product design technology reproduction, that is, reverse analysis and research on a target product, so as to deduce and obtain the design elements such as the processing flow, organizational structure, functional characteristics and technical specifications of the product, in order to produce Products with similar functions but not exactly the same, reverse engineering originates from hardware analysis in the commercial and military fields, and its main purpose is to directly derive product design from product analysis when necessary production information cannot be easily obtained Principle, with the popularity of computer-aided design, reverse engineering has become a method that can construct 3D virtual models through CAD, CAM, CAE or other software based on existing physical components. The real object can be measured by 3D scanning technologies such as CMMS, laser scanner, structured light source converter or X-ray tomography

This application claims the benefit of Korean Patent Application No. 10-2016-0084835, filed with the Korean Intellectual Property Office on Jul. 5, 2016, the disclosure of which is incorporated herein by reference in its entirety.[19] Generally, the structure of a silicon chip forming an integrated circuit may include transistors and metal layers. The metal layers connect transistors as digital logic devices that enable the silicon chip to function as a processor or an encryption engine. Various methods can be used to obtain information regarding the silicon chip from the chip itself, and in an integrated circuit used in a smart card in particular, an attacker may use information obtained from analyzing, or reverse engineering, the integrated circuit to alter the operation mode of the circuit or manipulate the data stored in the memory. Such methods can incur undesired results, especially in security-related circuits associated with ATM card functions or access-control functions.

CN213585924U • 2021-06-29 • ZHILAIZHIWANG TIANJIN CULTURE COMMUNICATION CO LTD Earliest priority: 2020-12-29 • Earliest publication: 2021-06-29 [20] Scanners are usually used as external computer equipment, by capturing images and converting them into digital input devices that the computer can display, edit, store, and output. The scanner can scan photos, text pages, drawings, art drawings, photographic negatives, film films, and even 3D objects such as textiles, sign panels, printed circuit board samples, etc., and extract and combine original lines, graphics, text, and photos. The plane object is converted into a device that can be edited and added to the file. Scanners belong to the input system of computer-aided design. Through computer software and computer, output device interfaces, they form a pre-screen computer processing system, which is suitable for office automation and is widely used in sign panels, printed boards, and printing industries.

CN102622479A (B) • 2012-08-01 •UNIV ZHEJIANG [21] Reverse engineering is the general term for computer-aided technology, digital measurement technology, and geometric model reconstruction technology that convert product prototypes into digital models. It is an important technical means for digesting and absorbing advanced technologies to achieve rapid development of new products. Reverse engineering technology is widely used in many fields such as industrial production, scientific research and social life, and its implementation process. In industrial production, there are a batch of parts whose geometric models can be expressed using a limited set of solid primitives, a set of geometric transformation operations and a set of Boolean set operations, where the solid primitives include spheres, right-angled hexahedrons, cylinders, For cones, pyramids, etc.,

Adaptive laboratory evolution and reverse engineering enhances autotrophic growth in Pichia pastoris.Gassler T, et al. Metab Eng. 2022. PMID: 34800702 Free article [22] Collagen is the primary component of the extracellular matrix in the human body. It has proved challenging to fabricate collagen scaffolds capable of replicating the structure and function of tissues and organs. We present a method to 3D-bioprint collagen using freeform reversible embedding of suspended hydrogels (FRESH) to engineer components of the human heart at various scales, from capillaries to the full organ. Control of pH-driven gelation provides 20-micrometer filament resolution, a porous microstructure that enables rapid cellular infiltration and micro-vascularization, and mechanical strength for fabrication and perfusion of multiscale vasculature and tri-leaflet valves. We found that FRESH 3D-bioprinted hearts accurately reproduce patient-specific anatomical structure as determined by micro-computed tomography.

Sheng Wu Yi Xue Gong Cheng Xue Za Zhi. 2015 Feb;32(1):225-8[Article in Chinese] Ao Fang, Min Zheng, Ding Fan PMID: 25997297.[23] Artificial bone replacement has made an important contribution to safeguard human health and improve the quality of life. The application requirements of rapid prototyping technology based on reverse engineering in individualized artificial bone with individual differences are particularly urgent. This paper reviewed the current research and applications of rapid prototyping and reverse engineering in artificial bone. The research developments and the outlook of bone kinematics and dynamics simulation are also introduced.

Reverse engineering of metabolic pathways from observed data using genetic programming. Koza JR, et al. Pac Symp Biocomput. 2001. PMID: 11262962 Free article.[24] Recent work has demonstrated that genetic programming is capable of automatically creating complex networks (such as analog electrical circuits and controllers) whose behavior is modeled by linear and non-linear continuous-time differential equations and whose behavior matches prespecified output values. The concentrations of substances participating in networks of chemical reactions are also modeled by non-linear continuous-time differential equations. This paper demonstrates that it is possible to automatically create (reverse engineer) a network of chemical reactions from observed time-domain data.

3d printer and dual nozzle guiding module thereof us2021299954a1 • 2021-09-30 • infinity 3d printer co ltd

[25] 3D printing technology is also known as additive manufacturing (AM), which refers to a process of outputting physical materials in a layered manner to form 3D articles based on 3D model images. The current common 3D printers on the market use fused deposition modeling (FDM) technology, which can output molten materials through single nozzle or multiple nozzles, and control the path of the nozzle outputting materials according to a computer. A modeled article can be formed through stacking and solidifying of the materials layer by layer. During the formation, a single nozzle printer can only produce articles of single color or the same material in a single process, otherwise the printing process must be interrupted to replace the yarn. However, the steps of nozzle cleaning, yarn heating and software setting are time-consuming and labor-intensive. Therefore, a 3D printer with two or more nozzles is more suitable for producing complex and high-quality articles

Mendoza, Hannah Rose (15 May 2015). "Alain Le Méhauté, The Man Who Submitted Patent For SLA 3D Printing Before Chuck Hull". 3dprint.com.[26] Alain Le Méhauté, Olivier de Witte, and Jean Claude André filed their patents for the stereolithography process three weeks *before* Chuck Hull but their applications were abandoned by the French General Electric Company (now Alcatel-Alsthom) and CILAS (The Laser Consortium). However, far from seeming bitter, the grand duke of 3D printing is as proud as ever of their innovative work and he passionately advocates for the value of the technology. Writer from Primante3D Alexandre Moussion caught up with Le Méhauté in the hopes of honoring the true inventors of this revolutionary technology and to hear how his analysis of the phenomenon has developed in the intervening 30 years. Moussion sees this story as yet another example of French innovation that fails to come to fruition for the benefit of France

History of 3D Printing: When Was 3D Printing Invented?". *All3DP*. 10 December 2018. Retrieved 22 November 2019.[27] 3D printing's come a long way since its start, but when was that? If, like most people, you think of 3D printing as a new technology, you're in for a surprise. While it's true that the industry has made massive leaps forward in recent years, it's all building on a base that goes back almost a century. Since those early days, 3D printing has come to refer to a variety of specific technologies, some of the most common being fused deposition modeling (FDM), stereolithography (SLA), and selective laser sintering (SLS). The first peaks of 3D printing came when each of these technologies was developed, patented, and trademarked.The next leap forward came when these patents began expiring and more people could experiment with the technology. It's this period of time, when FDM printing exploded in popularity, that many people mistakenly think of as the origins of 3D printing.

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We are delighted to present the initial project report on 'Disc Brake Caliper Hub'. Our heartfelt thanks go to our internal guide Mr. P. Ravikiran for their unwavering assistance and guidance throughout the project. We are truly appreciative of their valuable suggestions, which proved to be extremely beneficial. We would also like to express our gratitude to the HOD, Dr. B. Vijaya Kumar, Guru Nanak Institute of Technology, Hyderabad, India, for their invaluable support and recommendations, which have been instrumental in the success of this project.

REFERENCES

1. Hydraulic transmission brakes. RUBURY, J. M., Park Hall, Bradwell, Braintree, Essex. Oct. 6, 1930, No. 29937.
2. Fluid-pressure brakes. HALL, F. H., Cleeve Cottage, Holford, near Bridgewater, Somerset. Sept. 2, 1931, No. 24622.
3. Raymond J. Norton, Washington, D. C., assignor to Bendix Brake Company, South Bend, Ind., a corporation of Illinois Application January 9, 1931, Serial No. 507,687 4.
4. Niels Peter Valdemar Biniff, Copenhagen. Denmark Application October 20, 1930, Berial No. 489,990 In Denmark October 22, im I Claim (CL 139-72).
5. William Leicester Avery, Thorley, Bishop's Stortford, England Application November 2, 1932, Serial No. 640,886 In Great Britain November 12, 1931.
6. V-TYPE BRAKE FOR MOTOR VEMCLE 2 Robert A. Poage, Panhandle, Tex., and Marlin Z.Poage, Tallahassee, Fla.Application June 27, 1935, Serial No. 28,738 Renewed November 11, 1936.
7. Ludger E. La Brie, South Bend, Ind., assignor to Bendix Brake Company, South Bend, Ind., a corporation of Illinois Original application April 23, 1931, Serial No. 532,265 Divided and this application May 31, 1935, Srial No. 24,388.
8. Joseph A. Forbes, Detroit, Mob., assignor to Kelsey-Hayes Wheel Company, Detroit, Mch., a corporation of Delaware Application July 21, 1941, Serial No. 403,435 I Claim.
9. Homer T. Lambert,. St. -Joseph, Miek,-.asgignor to Lambert Brake, Cooperator, St.i Joseph, Mich._ a corporation- of Michigan Application June- 29, 1944" 6 Claims. (Cl. 198-7-2).
10. Homer T. Lambert, St. Joseph, Mich., assignor to Lambert Brake Corporation, St. Joseph, Mich., a corporation of Michigan Application May 28, 1943, Serial No. 488,864 6 Claims. (Cl. 188-72).
11. Ellery R. Fltch, Elyria, Ohio, assignor to Bendix Westing house Automotive Air Brake Company, Elyria, Ohio, a corporation of Delaware Application August 23, 1943, Serial No. 499,683 1 2 Claims.
12. Patented Apr. 1Z 1949 2.94669990 UNITED STATES PATENT. OFFICE 2,466,990 SINGLE DISK BRAKE Wade C. Johnson, Cuyahoga Falls, Harry A.
13. Orby Bryant, Rolla, Mo. Application August 17,1949,

Serial No. 44,677 1.

14. John G. Maitin, South Bend, 4nd., #ssignor to Bendix Aviation Corporation,.South-Beimd"-I[nd., a corporation'df3D6Iawar_e ry -Application4anua _23, 1946, Sefiir.Vo. 42,919 6.Cloiims. (CI-60-54-A A).

15. Maurice Odile Dubois and Bernard Maurice Dubois, Soisy-sur-Montmorency, France Application February 26, 1947, Serial No. 731,154 In France November 28, 1945 Section 1, Public Law 690, August 8, 1946 Patent expires November 28, 1965 2 Claims. (Cl. 60-54.5).

16. Joseph Warwick Kinchin, Lowsonford, near Lapworth England, assignor to Girling Limited, Birmingliam" England, a British company Application August 19, 1952, Serial No. 305,154 Claims priority, application Great Britain August 21, 1951 11 Claims. (Cl. 188-152).

17. Thayer, Ken. "How Does Reverse Engineering Work?". *globalspec*. IEEE Global Spec. Retrieved 26 February 2018.

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21. CN102622479A (B) • 2012-08-01 •UNIV ZHEJIANG .

22. Adaptive laboratory evolution and reverse engineering enhances autotrophic growth in Pichia pastoris. Gassler T, et al. Metab Eng. 2022. PMID: 34800702 Free article.

23. Sheng Wu Yi Xue Gong Cheng Xue Za Zhi. 2015 Feb;32(1):225-8[Article in Chinese] Ao Fang, Min Zheng, Ding Fan PMID: 25997297.

24. Reverse engineering of metabolic pathways from observed data using genetic programming. Koza JR, et al. Pac Symp Biocomput. 2001. PMID: 11262962 Free article.

25. 3d printer and dual nozzle guiding module thereof us2021299954a1 • 2021-09-30 • infinity 3d printer co ltd.

26. Mendoza, Hannah Rose (15 May 2015). "Alain Le Méhauté, The Man Who Submitted Patent For SLA 3D Printing Before Chuck Hull". 3dprint.com.

27. History of 3D Printing: When Was 3D Printing Invented?". *All3DP*. 10 December 2018. Retrieved 22 November 2019.