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COMPOSITE CYLINDRICAL STRUCTURE AND METHOD OF MAKING IT

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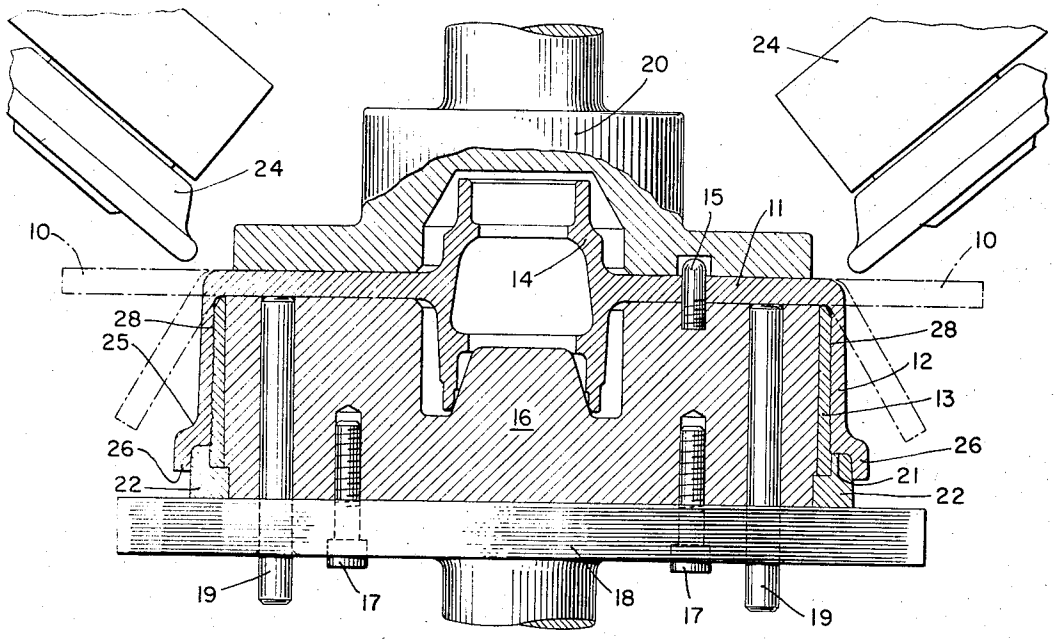


Fig. 1

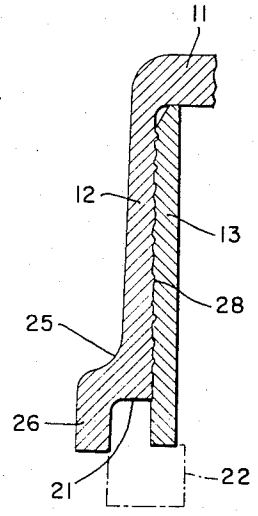


Fig. 2

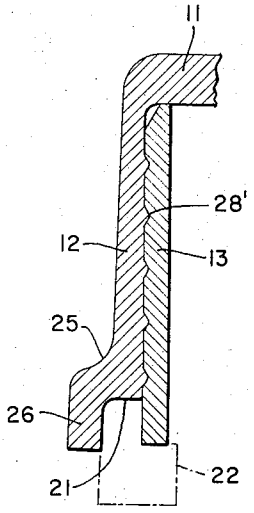


Fig. 3

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COMPOSITE CYLINDRICAL STRUCTURE AND METHOD OF MAKING IT

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This invention relates to a composite method of making a cylindrical structure and has for an object the provision of improvements in this art. The invention has been developed especially in connection with composite brake drums for automobiles in which a preformed ferrous liner is secured in a cold roll-shaped mounting body and will be described specifically for this application for purposes of illustration.

According to the present invention a liner of strong wear-resistant material, such as cast iron or steel, is secured on a hard spinning mandrel and is enveloped by roll-forming a cylindrical shell of deformable metal thereabout, whereby the liner is so strongly embraced by the work-shaped shell that a strong composite unit which resists separation is formed. The connection between the liner and the shell is improved by providing the liner with a roughened interface surface and applying sufficient pressure during the roll-forming of the shell as, with the heat generated in cold-rolling, to cause the material of the shell to flow into the indentations of the liner. The liner remains in a substantially cold state whereas the shell is heated by the cold-rolling action to such an extent that the desired flow at the interface is produced under the very high working pressure employed. Even though it has been found that during brake use, the braking temperature up to the fade temperature, beyond which there is no further increase, is greater than the temperature produced during formation of the shell, there is no tendency toward separation of the parts.

Heretofore it has been proposed to cast a shell around a liner. There are a great many patents disclosing various forms of this idea. One which is of some interest is that of Bauer 3,069,209, Dec. 18, 1962, this showing a liner with a roughened outer surface which is suggested to be produced by the method disclosed in the patent to Myers 2,623,809, Dec. 30, 1952.

The present invention may use a liner of centrifugally cast metal with a surface roughening produced in accordance with the Myers patent; but instead of casting an enveloping shell or jacket around the liner, as proposed by the Bauer patent, the present invention forms the shell directly from cold solid metal by roll-forming it under very high pressure in general accordance with the method of roll-shaping disclosed in the copending application of Albertson et. al., S.N. 248,023, filed Dec. 28, 1962, now Patent No. 3,262,191, assigned to the same assignee as the present application. The roll-forming machine proposed for use in the Albertson et al. application, in one form at least, is known in the commercial field as a "Hydrospin" machine, marketed by the Meta-Dynamics Division of Cincinnati Milling Machine Co. of Cincinnati, Ohio, and is generally described in Patents Nos. 2,960,951 and 2,975,743. These roll-forming machines employ very high roll pressures of from 50,000 to 300,000 pounds; and the Albertson et al. application discloses a method of using such machines with improvements to cause the metal to retain its shape without springback, especially

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in zones of reverse curvature and straight axial disposition. This may be referred to as a form-stable shape. The present invention avails of the benefits of the Albertson et al. method for straight axial rolling although not necessarily limited to a right cylindrical shape and including some conicity or other departures if desired.

As to the drum brake art specifically, there have been many and various designs but the three main lines of commercial production have been: (1) to make an integral all-cast drum and head; (2) to centrifugally cast a liner in a preformed shell having a drum and head; and (3) to cast a drum on a preformed head.

According to the present invention, the outer portion of a flat disk shape is rolled down upon a preformed liner. The disk blank may be the flange of a preformed hub unit or may be a head member adapted to be attached to a hub flange. The former is selected for illustration herein.

With the above introduction to the pertinent fields of art, it is to be noted that one of the particular objects of the present invention is to produce a shell-embraced liner type of composite structure which has superior characteristics, particularly as embodied in a brake drum.

Another object is to provide an improved method for making a composite structure comprising a preformed liner and a supporting body.

Another object is to provide an improved method of securing an interlocked interface connection or bond between a liner and a supporting shell therefor.

The above and other objects of the invention, as well as various features of novelty and advantages, will be apparent from the following description of an exemplary embodiment, reference being made to the accompanying drawings, wherein:

FIG. 1 is an axial section, partly in elevation, showing somewhat diagrammatically one form of apparatus for making a composite liner and drum shell, in the form shown the drum head being made integral with a forged hub;

FIG. 2 is an enlarged partial section showing one form of interface connection or bond between a liner and shell;

FIG. 3 is a section like FIG. 2 but showing a modified form of interface connection or bond.

As shown in the drawings, a preformed disk **10** of workable metal, such as work-hardenable steel, is provided to form the head **11** and cylindrical enveloping shell **12** of a brake drum which has a preformed cast-iron or steel liner **13**. The original outer edge of the disk **10** is shown in broken lines. Also in broken lines, the outer edge of the disk is shown in a partly bent down position.

The disk **10** is shown here as being the press-formed flange of a forged hub body **14** but it may be a simple head disk separate from the hub, positioned by pilot pins **15** on mandrel **16**.

The preformed liner **13** is tightly fitted on a very hard metal mandrel **16**, as of a hard steel which has minimum spring or compressibility, with an oil or other parting material therebetween or a draft angle, or both, to facilitate the later removal of the formed composite structure from the mandrel.

The mandrel **16** is secured, as by screws **17**, to a rotary headstock **18**, ejector pins **19** being provided for driving the composite structure off the mandrel after formation. The disk **10** is clamped to the mandrel **16** by a rotary tailstock **20**.

When it is desired to form a sealing groove **21** in the end of the drum an annular ring **22** is provided on the base of the mandrel **16**.

Rolls **24** are shown in starting position for rolling down the outer edge of the disk **10** to form the drum shell **12**. These rolls are forced inward and downward under very high pressure and are controlled in their travel by position-control means on the rolling machine, such as a templet or tape code control means, to accurately form the shell to the desired thickness and contour. With such a machine operated in accordance with the Albertson et al. disclosure the reverse curve portion **25** and the cylindrical portion of the offset annular end flange **26** are readily formed by the power rolls **24**. These machines and their operation are fully explained in the patents and application referred to above and need not be further described herein.

The roll-forming action causes the metal of the shell to tightly embrace the liner and even flow radially inward, the shell metal being made form-stable and without springback tendency by the method of rolling and there is a very strong interface connection between the liner shell which will resist great forces, such as torque and thrust, tending to produce separation between the parts; however, for a better connection the outer surface of the liner may be provided with a roughening so as to have projections and indentations around and into which the metal of the shell is caused to flow by the high pressure and heat generated by cold-working.

FIG. 2 illustrates one form of roughening **28** produced by centrifugally casting the liner in accordance with the Myers patent method, this roughening being referred to as a "Spinylock" finish. The area of interface contact is more than doubled by this finish. FIG. 3 shows machined grooves **28'**, which may be spiral, parallel, radial, or crossed, as may be desired.

It is to be noted that as the shell is heated by the cold-forming action, the liner remains at a substantially lower temperature. The shell is work-strengthened due to cold-forming and is raised to about 300 to 400° F., depending on the rate of cold-forming. Thus the shell material not only is cold-formed and flowed into the roughened surface of the liner but is subsequently shrunk upon the liner upon cooling. The differential of temperature between the liner and the shell during cold-forming is substantially higher than the differential of temperature attained during use of the brakes, hence there is no tendency to separate in actual use.

One of the problems formerly associated with composite brake drums has been the build-up of heat during braking at the boundary between the liner and the shell. By employing the hereinbefore mentioned "Spinylock" cast iron liner the surface area at the boundary between the liner and the shell is more than doubled. So long as the coefficient of heat transmission is not reduced by half, as is the actual case, the heat gradient throughout the composite liner remains substantially uniform and without heat build-up which would affect the operation of the drum. Thus, it can be seen that an increase in the boundary area between the shell and the liner completely compensates for any reduction in heat transmission due to a boundary layer.

Attention has largely been directed to the roll-forming of a steel shell but it is to be understood that shells of other metals, such as aluminum alloys or other materials which are suitable to the process and intended uses, may be used. Aluminum alloy shells on steel liners are particularly suitable for forming engine cylinders, for example. In this case the disk may need only enough head portion to hold it against axial displacement as the cylindrical shell portion is rolled down. Herein, when a drum is referred to the combination may include the bare drum alone or the drum and appurtenant parts, such a hub and hub flange and the like.

Operation according to the method will be obvious from the above description. After the liner and disk are secured in working position the rolls are forced against the disk and brought downward and inward under high pressure under control of a templet or the equivalent control means to work-roll the shell down on the liner; in the case of the end-grooved drum brake shown, to form the metal around the annular ring **22** to leave the end groove **21** between the end of the liner **13** and the end of the offset flange **26**. After formation, the composite structure is forced off the mandrel **16** and ring **22** by pressing or striking the knockout pins **19**.

During the forming action the inner surface of the liner is smoothed and to some extent work-hardened by pressure against the mandrel. The shell is given an elongated and somewhat spirally disposed grain structure and, if of work-hardenable metal like steel, is also cold work-hardened in the roll-forming action.

It has been found by inspecting cut sections that the metal of the shell is fully embedded in the roughened outer surface of the liner and that the liner and shell are so strongly connected as to resist separation and to act like a single integrated structure. By visual inspection and simple tests it can readily be ascertained that the shell has been cold-rolled down on the liner. Also it has been found by tests that brake liners having shells formed according to the invention and with the extended surface area of interface contact described have much greater thermal transfer and much less tendency to separate than composite drums made in other ways.

While one embodiment and a slight modification in detail have been described for purposes of illustration, it is to be understood that there may be various embodiments and modifications within the general scope of the invention.

We claim:

1. The method of forming a composite cylindrical metal structure which comprises, securing a metal liner on a hard rotary mandrel, securing a metal disk on the mandrel beyond one end of the liner, and roll-forming an annular edge of the disk under high pressure down on the liner with sufficient heat differential to heat-shrink the shell formed from the disk down on the liner.

2. The method of forming a composite cylindrical metal structure which comprises, securing on a hard rotary mandrel a hard cylindrical liner having a roughened surface on the side away from the mandrel, securing a metal disk on the mandrel beyond one end of the liner, and roll-forming an annular edge of the disk under sufficient and pressure to force the metal of the disk down against the roughened interface surface of the liner and into the roughened indentations of said interface surface of the liner with sufficient heat differential to heat-shrink the shell formed from the disk down on the liner.

3. The method set forth in claim **1**, which further comprises, providing a ring on said mandrel again the exposed surface of said liner, and roll-forming the end of said shell on ring to form an offset flange which, with the end of said liner, forms an end groove for said structure.

4. The method as set forth in claim **1**, which further comprises, providing a hub with a flange, the outer edge of which is roll-formed to comprise said shell.

5. The method of forming a brake drum comprising a cast iron liner with a roughened outer interface and a steel shell integral with the flange of a hub, which comprises, securing on a hard rotary metal mandrel a hard cylindrical cast iron liner having a roughened outer interface surface, securing the flange of a forged work-hardenable steel hub flange unit on the mandrel with the outer edge of the flange projecting beyond the outer surface of an end of the liner, and cold-rolling the outer edge of said flange under heat and pressure while the liner remains relatively cool to force the metal of the flange down against the outer surface of said liner and radially inward into the roughening of its outer interface surface with sufficient heat differential to heat-shrink the metal

of the shell formed from the flange down on the liner, creating sufficient interface surface contact to substantially eliminate the interface thermal barrier when the drum is used for braking.

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