March 9, 1943. J. H. L. DE BATS 2,313,227

ROLL FOR METAL-ROLLING MILLS

Filed Aug. 4, 1938 2 Sheets-Sheet 1

Fig. 1.

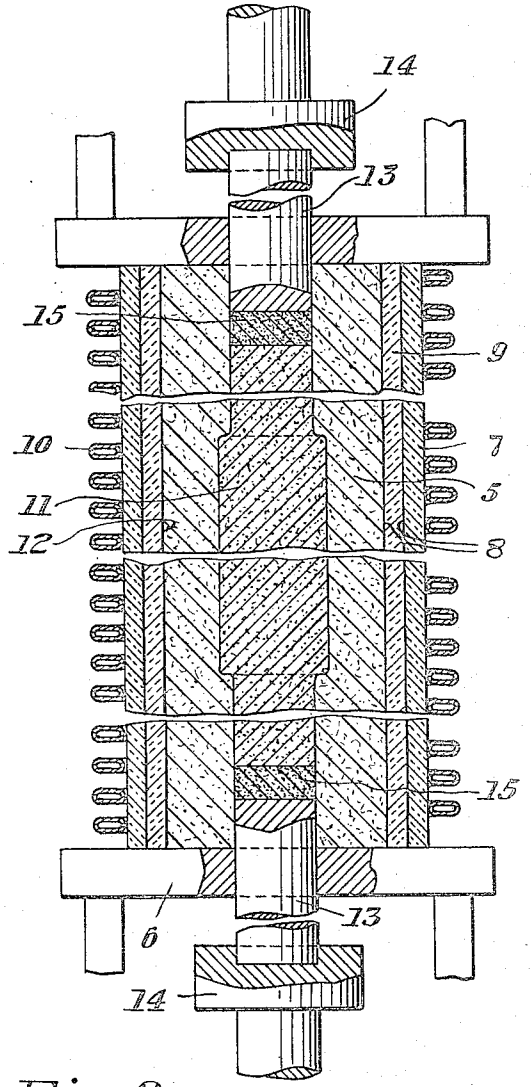
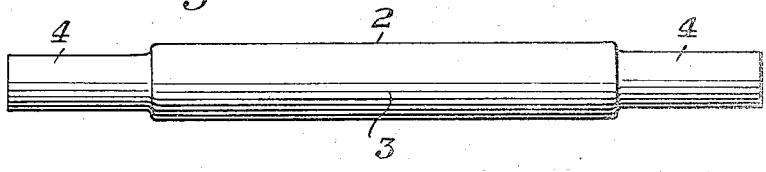


Fig. 2.



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Fig. 3.

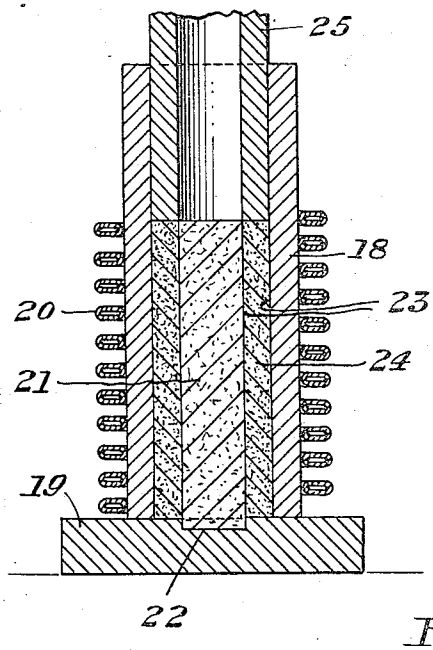


Fig. 4.

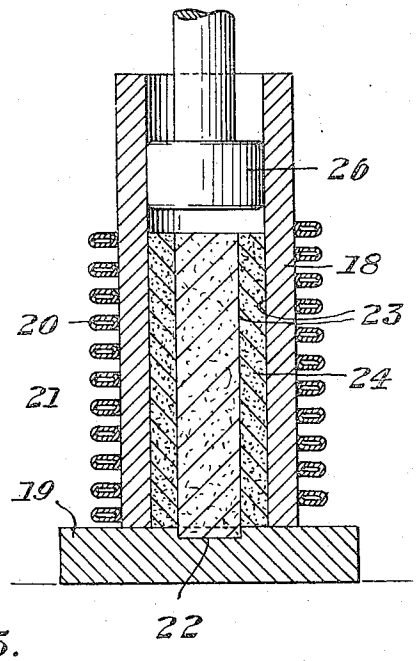


Fig. 5.

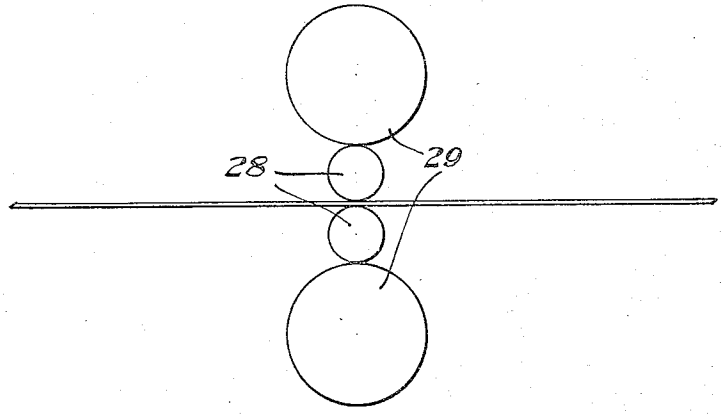
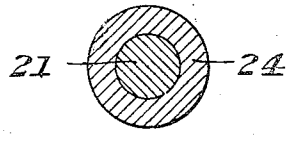


Fig. 6.



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ROLL FOR METAL-ROLLING MILLS

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Application August 4, 1938, Serial No. 223,056

12 Claims. (Cl. 80—58)

This invention relates generally to rolls for metal-rolling mills and more particularly to rolls made of hard cemented carbide compositions. The present application is a continuation-in-part of my copending application, Serial No. 751,768, filed November 6, 1934.

The rolls used in metal-rolling mills are subjected to enormous stresses, particularly those used in cold rolling. The pressures there encountered are oftentimes in the neighborhood of 40,000 pounds per inch of length of roll and sometimes in excess of 100,000 pounds per inch of length. Thus, in cold rolling strip which is 10'' wide, the total pressure on the roll may be in the neighborhood of 400,000 pounds or higher and where a strip 20'' wide is rolled, the total pressure may be approximately 800,000 pounds or higher. Accuracy of gage, freedom from crown and control of surface finish are highly desirable but these ends have not been wholly attained in prior known practices.

Heretofore the rolls have been made of alloy steel or high speed steel. None of these steels has proved entirely satisfactory but has been the best material which has been available, up to the time of the present invention.

I have discovered that cemented hard metal carbides possess certain properties, heretofore unknown, which render them pre-eminently suitable for metal-rolling mill rolls. A carbide roll has very little tendency to seize the strip and retains its shape under the conditions of heat and pressure during rolling to a much greater extent than prior known materials. It may, therefore, be used to make heavier reductions per pass and the mill may be run at greatly increased speeds. In addition to its great hardness, it takes a high surface finish, is free from pits and spalling, and has high torsional and beam strength.

I have found that remarkably improved results can be obtained in the rolling of metal, either hot or cold rolling, by employing cemented carbide rolls. The cemented carbide rolls employed in accordance with the present invention may be made in accordance with the methods disclosed in my previously referred to application, Serial No. 751,768, or in accordance with the application of myself and John A. Ritz, Serial No. 162,966, filed September 9, 1937, and perhaps by other processes known according to the prior art. Generally speaking, the process of making rolls, which, however, is not herein claimed, consists in heating at least one hard metal carbide, such, for example, as tungsten carbide, without additional cementing medium, or a mixture of one or more hard metal carbides with a metallic cementing medium to a temperature sufficient to cause bonding of the carbide particles when pressure is applied and while the composition is heated, exerting pressure on it, so as to cause cementing, bonding or welding of the hard metal carbide particles to themselves or to the cementing medium. The carbides may be used either with or without a metallic cementing medium.

In the accompanying drawings, which illustrate somewhat diagrammatically certain preferred embodiments of my invention;

Fig. 1 is a vertical section through a mold and furnace and parts of a press illustrating the manner in which a roll for a rolling mill may be made.

Fig. 2 is a side elevation of a hard metal carbide roll.

Fig. 3 is a vertical section through a mold and furnace illustrating the manner in which a sheath of hard metal composition may be made.

Fig. 4 is a view similar to Fig. 3, illustrating the manner in which the sheath, formed in accordance with Fig. 3, is united to a core by heat and pressure to form the body of a roll.

Fig. 5 is a vertical end elevation of a stand of a 4-high mill, in which the working rolls are made of hard cemented carbide composition, and

Fig. 6 is a vertical transverse section through a roll composed of a relatively tough core and a relatively hard sheath surrounding the core.

Heretofore, relatively small articles only have been made of cemented carbide compositions, such compositions having been used primarily for the small cutting tips of cutting tools, small drills, discs and for wire drawing dies. No case is known prior to my invention where the weight of the cemented carbide composition exceeded a few pounds. It was known that tungsten carbide cemented compositions were very hard, when made in small sizes, so that the sintering operation could be accurately controlled, but it was never suggested that such material could be used satisfactorily in the production of rolls for a rolling mill. This was in spite of the fact that tungsten carbide and other cemented carbide compositions have been employed for many years in the production of articles such as those above referred to.

I have found that cemented tungsten carbide or other hard carbide rolls are greatly superior to those heretofore in use and that they produce results which were unheard of prior to my inven-

tion. One of the important characteristics of a cemented carbide roll is its extreme hardness. The hardest alloy steel or high speed steel rolls on the market have a hardness of about 65, Rockwell C scale. As contrasted with this, a tungsten carbide roll containing about 87% tungsten carbide and about 13% cobalt or nickel has a hardness of about 88, Rockwell C scale. The hardness of the carbide roll may be considerably increased by increasing the carbide content of the roll. The roll may, for example, be made of approximately 100% hard metal carbide, or it may contain some metallic cementing medium. It is preferred that the hard carbide constitute the principal proportion of the cemented composition—that is, that it amount to at least 50% by weight of the total composition, and it may amount to as much as 99% or even 100% of the composition. The particular proportions of hard cemented carbide and metallic binding medium, if a binding medium is used at all, will depend on the particular application of the roll.

Although tungsten carbide is the preferred carbide, the invention contemplates the use of other hard metal carbides, such, for example, as the carbides of tantalum, titanium, chromium and molybdenum, or mixtures thereof.

The metallic cementing medium may be any metal, alloy or combination of metals which has a melting point below the melting point of the carbide with which it is used, and which has the property of wetting and cementing the carbide. I prefer to employ as auxiliary or bonding metals one or more of the metals cobalt, nickel or iron. However, I may employ other metals, such as manganese, chromium, molybdenum, copper, aluminum or beryllium, or mixtures or alloys of these metals. The amount of metallic cementing medium is preferably less than 50% by weight of the composition but in some cases where it is desired to produce a particularly tough roll, this proportion may be exceeded.

Although the size of rolls made in accordance with the present invention may vary greatly, I have made rolls having a barrel or body 3" in diameter and 20" long. The roll necks are 2½" in diameter and 6¼" long, making a total overall length of 32½". Such a roll weighs in the neighborhood of about 115 pounds. Because of its hardness, it takes an extremely brilliant mirror finish, the finish being comparable to a highly polished black marble. This finish may be produced by diamond grinding and lapping. The roll has a shear modulus which is almost 2½ times that of a similar size steel roll. In addition to its superior hardness and finish, the cemented carbide roll has many other superior properties as compared with the steel rolls heretofore used. There appears to be no reason why even larger rolls could not be made according to my process, should the occasion arise.

In cold rolling stainless steel strip, the maximum reduction or draft which it has been possible to take when employing alloy or high speed steel rolls without destroying their lustre has been approximately 10%. On the other hand, drafts of 15% can be taken on the same material, when employing cemented carbide rolls, without destroying their lustre, which, of course, would mar the finish or destroy the lustre on the strip. With the steel work rolls, if it is attempted to increase the reduction per pass beyond about 10%, the rolls produce objectionable "pickup." By pickup is meant that small particles of the steel strip appear to be pulled out of the surface of the strip and become embedded in the roll and this causes markings on the strip.

A comparison of the working life of cemented carbide rolls and alloy steel rolls shows most remarkable results. It has been found that cemented carbide rolls will roll from 10 to 50 times as much material as the best alloy steel rolls heretofore known, when employed under the same conditions. A pair of carbide rolls on which a record of the material rolled was kept has been used to roll almost 500 coils of low carbon, high carbon and stainless steel strip. The average number of coils of high finish which could be rolled with alloy steel rolls was approximately 10. Out of the approximately 500 coils which were rolled with the carbide rolls, something over 70 coils of stainless steel were rolled, every coil having saw tooth edges, which, of course, have a pronounced tendency to roughen the roll and shorten its life.

In another test, a pair of tungsten carbide rolls was used to roll an entire order of 20 coils of silicon steel containing about 3% silicon, and the rolling was stopped only because the order was completed. The rolls at the end of the operation showed no markings. If steel rolls has been used, a roll change would have been necessary at least every two or three coils, and perhaps oftener.

A comparative test between alloy steel and carbide rolls has been made by pairing an alloy steel roll and a carbide roll in the same mill. In this test, the carbide roll was used to roll the entire order of 21 coils of stainless steel strip and showed no markings when it was removed. On the other hand, the alloy steel roll had to be changed for each coil in order to produce the desired finish. A fresh steel roll was used to do the finish rolling on one coil and was then used to rough roll the next coil. The carbide roll, however, remained in the mill during all of the rough and finish rolling of the entire 21 coils and, even then, showed no markings and the lustre was suitable for further rolling when it was removed.

In another test in which 3" diameter tungsten carbide rolls were employed, 70,000 pounds, or 100 coils of high finish low carbon steel strip, were rolled without redressing or regrinding the rolls. The rolls were still suitable for further rolling of the same exacting finish after the entire order of 100 coils had been rolled. If alloy steel rolls had been used, five coils between roll changes would have been the maximum and the average would have been only four coils. This means that the use of carbide rolls saved approximately 25 roll changes, which would have been necessary in completing this order, each roll change requiring about 30 to 45 minutes.

There is a considerable amount of heat developed during the cold rolling of strip, particularly when high speeds and heavy reductions in thickness are employed. Steel rolls begin to show a straw color when the conditions are such that they are heated to a temperature of about 300° F. and this straw color mars the finish on the strip. On the other hand, the carbide rolls, when operated under the same conditions of speed and reduction per pass, do not become discolored and, therefore, do not discolor the strip.

Accuracy in rolling is a very important consideration. By employing carbide rolls, the dimensions of the roll pass, and, therefore, the dimensions of the rolled strip, can be maintained much more accurately than with steel rolls. I have found that the coefficient of expansion of a carbide roll under the conditions encountered

in metal rolling is only approximately 1/6 as much as for a steel roll. Furthermore, what little increase in dimensions does occur in the carbide roll is more evenly distributed throughout the whole body of the roll, and, therefore, does not tend to distort the roll appreciably. This comparative freedom from distortion of a carbide roll removes the speed limitation imposed on prior known metal-rolling mills.

The amount of power required for performing a given rolling operation using carbide rolls is less than that required with steel rolls. The carbide rolls, being harder, require less pressure to be exerted on the screw down mechanism and thus decrease the wear on the roll necks and bearings. The carbide roll does not swell noticeably in the center, as is the case with steel rolls, probably due to the very high heat conductivity of the carbide roll as contrasted with steel rolls. Even if the carbide rolls produced as much heat in the rolling operation as alloy steel rolls, they would be superior, because of the properties which have been referred to. However, it is believed that the actual amount of heat produced in a given rolling operation with carbide rolls is less than that which would be produced in the same operation with steel rolls. The carbide rolls have a lesser tendency to weld to or seize the steel strip and a lesser tendency to pick up particles of the steel strip, which would cause blemishes in the strip. The lower amount of heat developed by friction, when using carbide rolls as compared with steel rolls is believed to be partly due to the fact that the carbide rolls are of an entirely different chemical composition from the steel strip, whereas steel rolls and steel strip are of somewhat similar compositions. Also carbide rolls do not flatten under pressure as much as other rolls do.

Referring now more particularly to the accompanying drawings, a tungsten carbide roll **2**, such as illustrated in Fig. 2, may be made in accordance with the present invention. This roll, which is given by way of example, only, has a roll body **3**, which is 20" long and 3" in diameter. Each of the roll necks **4** is 2½" in diameter and 6¼" long, the whole roll weighing in the neighborhood of 115 pounds.

In making the roll, a powdered mixture of tungsten carbide or other hard metal carbide and an auxiliary metal, such as cobalt or nickel, is placed in the mold **5**, which may be of graphite or other suitable material. The mold rests on a supporting plate **6** and is surrounded by a shell **7** of quartz or other insulating material, which also rests on the plate **6**. The space **8** between the mold and the shell is filled with a heat insulating material **9**, which may be powdered lampblack or carbon, in order to protect the shell. Surrounding the shell **7** is the coil **10** of an induction furnace. The individual windings of the coil **10** may all be connected to a common terminal, so as to heat the charge uniformly, or the individual windings may be connected by individual electric current supplies, so that each winding may be controlled separately, in order to develop heat locally in any horizontal section of the mold. Preferably the heat is applied locally and progressively lengthwise of the charge in the mold as it has been found that this decreases the tendency of the charge to stick to the mold wall. Sticking is objectionable in the production of very dense articles, since it prevents the even transmission of pressure to all parts of the charge.

After the powdered mixture **11** of hard carbide and auxiliary metal is placed in the mold cavity **12**, electric current is supplied to heat up the charge to a temperature such that the powdered mixture may be cemented or welded together, in order to conform to the shape of the mold, when pressure is supplied to the heated mixture. Pressure is applied to the mixture **11** by means of plungers **13**, which form parts of a suitable press, the plungers being connected to the heads **14** of the press. In the embodiment shown, both upper and lower plungers are employed, so that the pressure is exerted on the powdered mixture from both ends but a single plunger may be used, if desired. A plate **15**, such as a graphite plate, is preferably interposed between each of the plungers **13** and the powdered mixture which is to be compressed.

In carrying out the operation, the powdered mixture may be heated to a temperature between about 1400 and 2500° C., depending upon the particular composition which is being cemented. Where a mixture containing about 87% tungsten carbide and 13% nickel or cobalt is used, I prefer to heat the mixture to a temperature of about 1500° C. As the proportion of hard metal carbide is increased and the proportion of binding metal is decreased, the temperature to which the mixture is heated should be increased. Thus, where the carbide constitutes, say, 98 or 100% by weight of the entire mixture, the cementing temperature would be of the order of 2500 or 2600° C. After the required temperature has been reached, the powdered mixture in the mold cavity **12** is compressed by operating the plungers **13**, so as to cause the hard carbide particles to be welded or cemented together by the metallic cementing medium. The pressure exerted through the plungers **13** may be either a continuous one or an intermittent one constituting a series of rapid hammer blows.

In Figs. 3 and 4, I have shown diagrammatically apparatus which may be employed in forming a roll body having a roll sheath of hard metal carbide surrounding the body and welded thereto. As shown in Fig. 6, the roll consists of a sheath **24** surrounding a core or body **21**, the sheath being relatively hard, as compared with the body, and the body **21** being relatively tough, as compared with the sheath. The sheath may, for example, be made of a mixture of tungsten carbide and cobalt or nickel in the proportion of about 90% tungsten carbide and 10% nickel, whereas the body or core **21** may contain substantially less carbide and more binder than the sheath. Instead of controlling the hardness and toughness by the relative proportions of the same carbide and auxiliary metal, these properties may be controlled by employing a different carbide or carbides for the sheath and a different carbide or carbides for the core or body.

Referring to Fig. 3, a mold **18** resting on a plate **19** is surrounded by an induction coil **20**. A core **21** is placed within and spaced from the inner wall of the mold **18** and rests in a seat **22** provided in the base **19**. The core and mold provide an annular space **23** between them, into which powdered material which is to form the sheath of the roll is introduced. The powdered mixture **24**, after having been introduced into the chamber **23**, is compressed by an annular plunger **25**. This compression may take place simultaneously with heating of the core and material **24** contained in the mold or the material **24** may simply be first compressed without the

use of any heat. In any event, after the powdered material **24** has been compressed about the core **21**, it, together with the core material, is brought up to a suitable welding temperature and is then subjected to the action of a plunger **26**, as shown in Fig. 4, which exerts pressure both on the core and on the surrounding sheath material **24**, to consolidate and densify the sheath material itself and to weld it to the core. Thereafter the core with the sheath welded thereto is removed from the mold and roll necks are applied to the roll body by employing a suitable mold, such, for example, as that shown in Fig. 1.

The sheath **24** consists principally of a hard metal carbide and may or may not contain auxiliary or cementing metal. The core **21** may be made either of a cemented carbide composition or of another type of material. It may, for example, be made of nickel or nickel alloy but is preferably of a cemented carbide composition which is relatively tough as compared with the sheath.

Instead of forming the sheath from powdered material while in contact with the core, it may be formed separately, then placed in position around the core and the assembly heated and pressed to unite the preformed sheath with the core.

The invention is not limited to any particular hard metal carbide, although tungsten carbide is preferred. I may, for example, use the carbides of tantalum, titanium, chromium, molybdenum or vanadium or other hard carbides, in place of or in addition to the tungsten carbide. Also, although the preferred metallic cementing medium is cobalt or nickel, I may employ iron, manganese, chromium, molybdenum, copper, aluminum, beryllium or mixtures or alloys of such metals or, in fact, any metallic cementing medium which has a lower melting point than the carbide with which it is associated.

The invention has been described particularly in connection with a roll for a rolling mill for use in cold rolling steel. It has been found particularly suitable in forming the working rolls, such as rolls **28** shown in Fig. 5, which rolls are used in conjunction with larger backing rolls **29** in rolling the strip **30**. The invention, however, is not limited to the production of a working roll for 4-high mills but may be used in other types of mills. Also the roll is not limited to use in connection with the rolling of steel but may be employed in rolling other metals.

Although I have illustrated and described certain preferred embodiments and proportions of materials which are to be employed in making my roll, it is to be understood that the invention may be otherwise embodied or practiced within the scope of the following claims.

I claim:

1. A roll for a metal rolling mill, said roll made of a cemented composition containing a substantial amount of hard metal carbide.

2. A roll for a metal rolling mill, said roll made of a cemented composition containing hard metal carbide bonded by metallic cementing medium having a lower melting point than the carbide, the carbide constituting at least 50% by weight of the cemented composition.

3. A roll for a metal rolling mill, said roll ma of a cemented composition containing hard me carbide bonded by at least one auxiliary metal the group consisting of cobalt, nickel and irc the carbide constituting at least 50% by weig of the cemented composition.

4. A roll for a metal rolling mill, at least t working surface of said roll being made of a c mented composition containing particles of ha metal carbide bonded by metallic cementing m dium having a lower melting point than t carbide.

5. A roll for a metal rolling mill, at least t working surface of said roll being made of a c mented composition containing particles of ha metal carbide bonded by at least one auxilia metal of the group consisting of cobalt, nickel a iron.

6. A roll for a metal rolling mill, at least t working surface of said roll being made of a c mented composition containing particles of ha metal carbide bonded by at least one auxilia metal of the group consisting of cobalt, nickel a iron, the carbide constituting at least 50% weight of the cemented composition.

7. A roll for a metal rolling mill, at least t working surface of said roll being made of a c mented composition consisting substantially hard metal carbide particles and metallic c menting medium therefor, one of the princi ingredients of said composition being tungs carbide.

8. A roll for a metal rolling mill, at least working surface of said roll being made of a mented composition containing about 50–98% weight of hard metal carbide, the balance of composition being a metallic cementing medi therefor and including from 2 to 50% by wei of the cemented composition of a metal of group consisting of cobalt, nickel and iron.

9. A roll for a metal rolling mill, at least working surface of said roll being made of a mented composition containing about 50–98% weight of tungsten carbide, the balance of composition being a metallic cementing medi therefor and including from 2 to 50% by wei of the cemented composition of a metal of group consisting of cobalt, nickel and iron.

10. A roll for a metal rolling mill, at least working surface of said roll being of a cemen composition consisting principally of hard me carbide.

11. A roll for a metal rolling mill, said roll cc prising a roll body and a sheath encasing the b and forming a working portion of the roll, sheath made of a cemented composition cons ing principally of hard metal carbide, the she being relatively hard as compared with the bc the body being relatively tough as compared w the sheath.

12. A roll for a metal rolling mill, said roll cc prising a roll body and a sheath encasing body and forming the working portion of the both the sheath and the body made of cemer compositions containing hard metal carbide, sheath being relatively hard as compared with body, and the body being relatively tough as cc pared with the sheath.

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