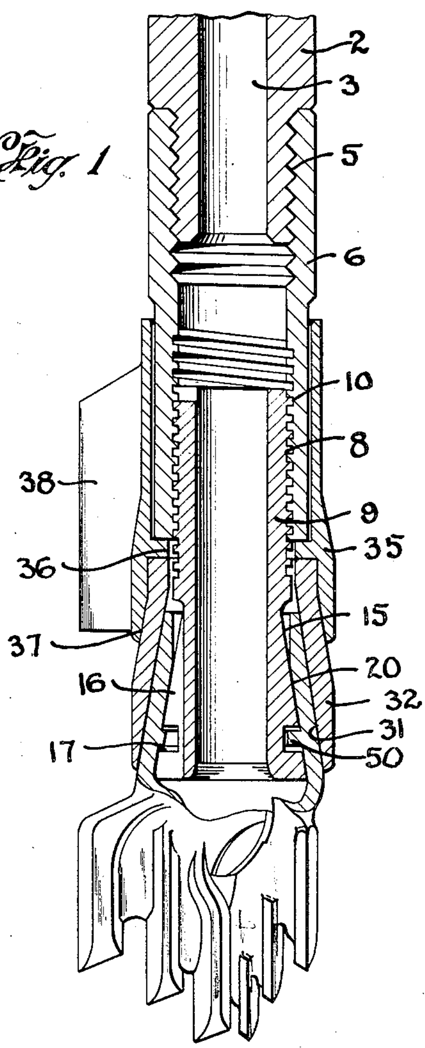
March 5, 1957 H. J. HAWTHORNE ET AL 2,783,973

DRILL BIT

Filed Feb. 20, 1951 2 Sheets-Sheet 1

Fig. 1



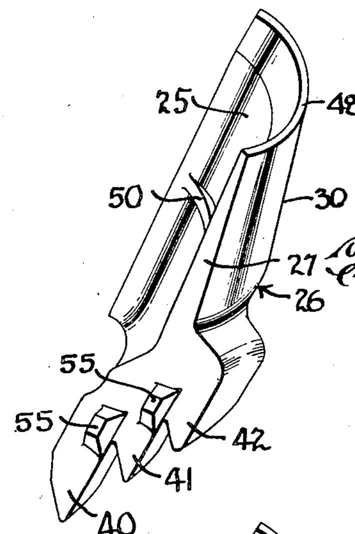


Fig. 2

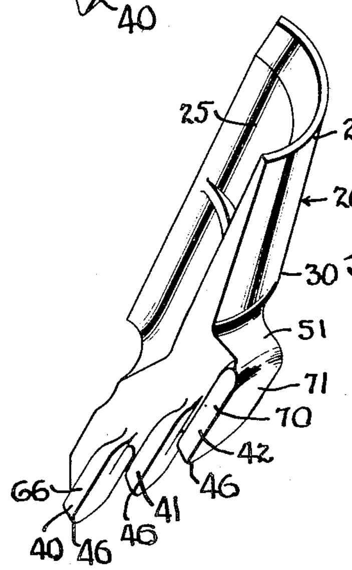


Fig. 3

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DRILL BIT

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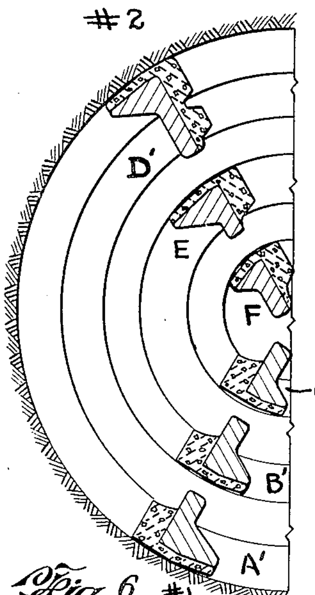

Fig. 6

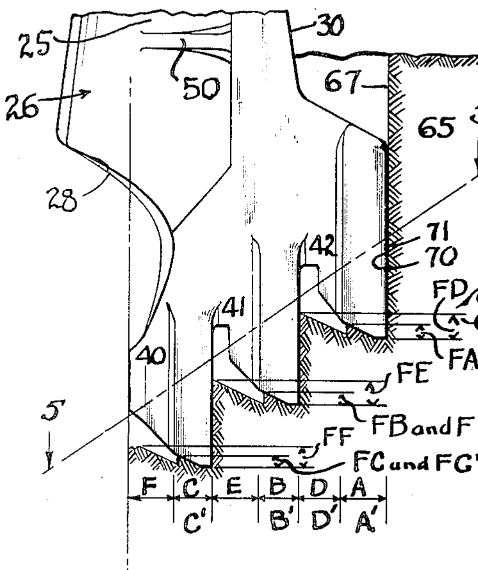

Fig. 4

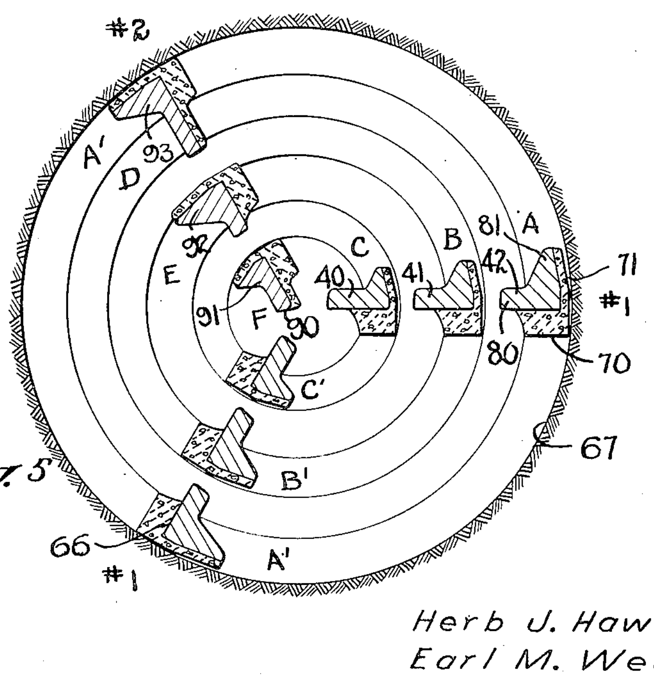

Fig. 5

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United States Patent Office

2,783,973

Patented Mar. 5, 1957

2,783,973

DRILL BIT

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Application February 20, 1951, Serial No. 211,957

5 Claims. (Cl. 255—61)

The invention relates to a drill bit of the type used in the rotary method of drilling where the bit is connected to the lower end of a section of pipe and the bore drilled by rotating the pipe and the bit in combination with the placing of weight on the bit and the circulation of drilling mud through the center of the bit in order to wash away the cuttings.

Since the inception of this type of drilling, difficulty has been encountered in the wearing away of the cutting blades. With the advent of deeper drilling, considerable time is expended in removing the string of drill pipes, say from a 10 or 15,000 foot hole by uncoupling the hundreds of sections of drill pipe which have been added so as to elevate the bit to the surface. The worn bit is then removed and a fresh bit attached whereupon the drill pipe is then lowered to carry the bit to the bottom of the well bores.

It had been found that in a majority of instances, there is practically no wear to the body of the drilling bit which is connected to the drill pipe and that practically the only wear occurs on the cutting edges or lower portions of the drilling bit.

In the prior application for patent of Herbert J. Hawthorne, Serial No. 612,416, filed August 24, 1945 for a Detachable Blade Bit now Patent No. 2,615,684 issued October 28, 1952 and also in the co-pending applications, Serial No. 794,239, filed December 29, 1947 now Patent No. 2,666,622 issued January 19, 1954 for a Detachable Blade Bit and application for patent of Hawthorne et al., Serial No. 70,622, filed January 13, 1949 now abandoned for a Finger Blade Drag Bit, certain types of detachable blade bits have been disclosed and claimed, and it has been found in actual practice that these general types of replaceable blade bits are entirely satisfactory and the claimed arrangement in such applications for holding the detachable blades in a secure position so as to avoid the loss thereof in the well bore has been exceptionally satisfactory.

The present invention is particularly directed to the detailed construction of the blade segments which may be detached when worn and replaced with new segments at a very nominal cost as compared with the cost of replacing the entire bit body.

It is therefore one of the objects of the present invention to provide a blade segment having an arcuate shank with portions thereon to be affixed to the bit body so as to present a plurality of radially spaced and circumferentially stepped abrading fingers to engage the bottom of the well bore as the bit rotates.

Another object of the invention is to provide radially spaced and circumferentially stepped abrading or cutting fingers which will cut circumferential tracks or track-ways in the bottom of the well bore in removing the earth formation to create the bore.

Another object of the invention is to provide a segmental blade-like member having radially spaced and circumferentially lower end stepped fingers which will both abrade and fracture the earth formation encountered in the bottom of the well bore.

A still further object of the invention is to provide a rotary drag bit replaceable blade structure wherein a plurality of blade segments are attached to the bit body where at least two of the segments are arranged with differently spaced and constructed fingers to create the well bore.

Still another object of the invention is to provide two contiguous blade segments carried by the bit body wherein the radially arranged fingers are differently spaced radially on two adjacent blade segments so that the fingers of the two blades acting together will cut track-ways which completely cover the bottom of the well bore being drilled.

A still further object of the invention is to provide two contiguous blade segments and a rotary detachable blade bit wherein such segments have downwardly radially spaced circumferentially stepped fingers so constructed and arranged that the fingers of one blade cut a plurality of radially spaced and circumferentially stepped depressed track-ways creating raised ridges between such stepped depressed track-ways.

It is also an object of the invention to provide a plurality of fingers on one of a plurality of detachable blade bits which will cut depressed track-ways leaving elevated ridges between such depressed track-ways in combination with a following blade segment having differently radially spaced fingers to fracture the upstanding ridges thus created so that the composite action of the two blades when taken together covers the bottom of the well bore to remove the formation and maintain during drilling a concave bore bottom.

Another object of the invention is to provide a detachable blade segment for rotary drilling bits wherein downwardly extending radially spaced and circumferentially stepped fingers of the base metal of the blade segment are provided.

Another object of the invention is to create a finger blade segment wherein the radially spaced fingers are substantially the shape of an L which is arranged to rotate in what may be said to be a backward circle so that one leg of the L termed the side is radially disposed while the other leg of the L termed the base will be circumferentially disposed and the heel of the L will be the forward rotating corner of the finger.

Another object of the invention is to provide a backward L finger for detachable blade segments having the hard material disposed on the forward face of the radial legs of the L and on the outer face of the circumferential leg of the L in such a manner that the size, shape, point of wear, and the arrangement of the blades will be such as to correlate the blade wear to obtain substantially uniform wearing of all of the fingers of the same blade segment or of the same segments on the same bit.

A still further object of the invention is to provide a detachable blade segment for finger bits wherein a projection of the base metal of the finger is disposed on the forward rotating face of the finger so as to form a support for a deposit of hard metal to provide an abrading face for the finger.

It is also an object to provide a three blade segment detachable blade bit wherein each segment has three radially spaced circumferentially stepped fingers wherein one of the blade segments of the bit may be designated as a blade segment to cause abrasion of the bore bottom by the arrangement, spacing, and construction of the fingers whereas another one of such blade segments for use in combination with the first segment shall constitute differently radially spaced fingers to fracture the earth formation which is not abraded away by the fingers of the first segment so that the two segments in combination will cover the bottom of the bore being drilled and remove the material partly by abrasion and partly by fracture.

Still another object of the invention is to provide a means and method of depositing hard material upon rotary drill bits cutting surfaces by the use of atomic hydrogen so as to insure the melting of the surface of the constant carbide particles so as to form a completely welded bond with the hard metal material and the base metal of the drill bit.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the accompanying drawings wherein;

Fig. 1 is a vertical cross sectional view of the assembled bit and parts in operating position;

Fig. 2 is a perspective view of one of the blade segments of the base metal before the application of the hard surfacing material thereto;

Fig. 3 is a similar section after the hard surfacing material has been applied to the base metal of the segment of Fig. 2;

Fig. 4 is an illustrative view of one of the blade segments which will be designated as the number **1** segment and illustrating the fingers in abrading position to create the trackways by removing the earth formation;

Fig. 5 is a section taken on the line **5—5** of Fig. 4 and showing the blade segment fingers in transversed section so as to illustrate the circumferential arrangement of the fingers and the relative position of the track-ways which are cut or created thereby;

Fig. 6 shows an arrangement similar to that of Fig. 5 but with a slightly modified construction of one of the fingers of the number **2** blade, the fracturing portion of the outer finger having a greater coating of hard metal thereon.

In Fig. 1, the drill collar or drill pipe **2** is caused to be rotated and the drilling mud is circulated through the passage **3** thereof to discharge from the bit in order to accomplish various functions of said drilling mud, such as carrying away of the cuttings, the cooling of the bit, the creating of a filter cake on the face of the well bore, and for maintaining the bore against caving, all of which are well known in the art.

The lower end of this pipe section **2** is threaded at **5** to receive a drive sub or nipple **6** which is threaded thereon. This drive sub in turn is threaded at **8** on a bit body **9** which has the upper threaded end **10** having a coarse acme thread to receive said drive sub **6**.

The bit body **9** is of peculiar construction in that it has a downwardly and outwardly tapered conical surface **15** adjacent its lower end which is provided with longitudinal circumferentially spaced grooves **16** and the annular recess **17** so as to create the blade segment supporting surfaces **20** thereon.

These surfaces **20** are arranged to receive the inside surface **25** of a blade segment such as **26**, shown in Figs. 2 and 3. The arcuate shank **27** is applied to the conical surface **20** and the plurality of shanks **27** of the several blade segments **26** serve to enclose the conical portion **15** of the body **9**.

Each of the blade segments **26** has an outer arcuate surface **30** which is arranged to receive the inner conical surface **31** of a clamping or driving collar **32**. This collar slides over the shank surfaces **30** and is forced into position by either the driving sub **6** or by the reamer section **35** which is shown in Fig. 1 as having an inwardly projecting rib **36**, the conical drive portion **37**, and the reamer blades **38** radially disposed thereon.

With this construction, the blade segments **27** are firmly clamped in position so that the fingers **40**, **41**, and **42** will extend downwardly to engage the bottom of the well bore which is being drilled and to abrade or fracture the formation which is encountered when weight is applied to the drill pipe **2** and rotation accomplished.

The various fingers may be differently spaced in radial position and the lower ends **46** thereof are stepped circumferentially so as to cut a generally concave bore bottom as best seen in Fig. 4.

Each of the blade segments **26** is a forging of a suitable steel or base metal and as heretofore indicated has a shank **27** having the inner arcuate surface **25** and the outer arcuate surface **30** which surfaces are relatively tapered upwardly and toward each other to provide a relatively thin arcuate upper end **48** on the segments.

The particular segments shown are of a size for use with a three-way or three-blade detachable blade finger bit and of such size and construction that the three shanks make up an annular portion to enclose the conical surface **15** on the bit body **9**. In order to prevent these blade segments from longitudinal movement an inwardly extending arcuate lug **50** is best seen in Fig. 2 and this lug is intended to be disposed in the recess **17** on the bit body.

In order to drill a bore which is larger in diameter than the pipe **2**, the fingers **40**, **41**, and **42** are radially arranged and with the inner finger **40** close to the center of the bit body the intermediate finger **41** spaced radially outwardly and upwardly from the first finger **40** and the outer finger **42** projecting a substantial distance outwardly from the shank **27** by virtue of the shoulder **51** which supports this outer finger **42**.

These fingers are radially spaced as seen in Figs. 2 and 3 and the fingers **40** and **41** in particular may have thereon a projecting lug **55** of the base metal so as to form a greater support and bonding surface for the body of hard material, such as **66** in Fig. 5 so as to obtain a maximum amount of wear and service from the bit without replacement of the fingers.

Fig. 4 shows one of the blade segments **26** in operating position cutting the earth formation **65** to create the well bore **67**.

By comparison with Fig. 3, it will be seen that this base metal blade segment **26** has had the lugs **55** thereof covered with the hard metal **66** so as to provide a wear surface **70** on the forward face of each of the fingers **40**, **41**, and **42**.

The outer circumferential faces **71** will also be covered with the hard metal in the form of a coating to maintain the gauge of the well bore or the track-way which is being cut by that particular finger.

By reference to Fig. 4, the particular abrading and fracture action will be readily apparent. For instance, the outer finger of the blade segment is shown as cutting the well bore **67** and also cutting a track-way which is indicated in Fig. 5 as the track-way A. This track is of the width of the hard surface material **70** on the finger **42** of Fig. 3, while the hard surface material **71** on the circumferential leg of the finger will be cutting the well bore gauge **67**.

This finger **42** as heretofore indicated may be designated as an **L** but is arranged to rotate in a clock-wise direction in looking down on the plan view of Fig. 5 so that the **L** rotates backwardly. The radial leg **80** thereof has the hard surfacing material in abundance thereon so as to provide a maximum wearing or abrading action before the blade segment is to be discarded. While the radial leg **81** has a thinner coating **71** of material merely to cut and maintain the gauge as distinguished from the maximum of abrasions which is to be obtained by cutting the track-way A as seen in Fig. 4.

This blade shown in Fig. 4 and in the horizontal position looking downwardly in Fig. 5 will be designated as blade number **1** and Fig. 5 shows that there are two such blades applied to the particular bit being illustrated where there is but one number **2** blade which extends upwardly and to the left as seen in Fig. 5. Particular attention is directed to the radial spacing of the fingers **40**, **41** and **42** of the blade number **1** to cut the track-ways A, B, and C as seen in Fig. 5. In looking at the side sectional view of Fig. 4, it will be seen that the blade **42** cuts the track-way A which is designated as being of a depth FA in Fig. 4

whereas the blade 41 cuts the track-way B which is of a depth FB in Fig. 4 and the inwardly most blade 40 cuts a track-way C of a depth FC.

It will be apparent therefrom that the number 1 blade therefore leaves the track-ways D, E, and F with the track-ways B and C alternated therebetween.

In this manner, there are relatively high ridges left as the track-ways D, E, and F as seen in Fig. 4. When, however, the number 2 blade following the number 1 blade in a clock-wise rotation comes to the position shown in the section of Fig. 4, then the blade shown at D will cut this track-way D fracturing the ridge D while also traveling in the track-way A as seen in Fig. 5 so it might be said that this blade on the outermost portion of blade 2 cuts a supplemental track-way A which is designated as A′ below the indicating line of Fig. 4, and the track-way D′ which is also indicated below the section line.

The second number 1 blade will cut the track-ways A′, B′ and C′ which are the same as A, B, and C.

The intermediate finger of blade number 2 will cut the track-way E between the track-ways B and C and the innermost finger of blade number 2 will cut the track-way F where the inner leg 90 of this blade extends to the center of the well bore and may be designated as a breaker finger. As a matter of fact, each of the three fingers of blade number 2 which may be designated as 91, 92, and 93 are all breaker fingers because they are breaking over the ridges which constitute the track-ways D, E, and F.

It seems apparent that if these ridges D, E, and F are fractured and in this manner removed or released that they permit a much faster abrading action by the fingers 40, 41 and 42 of the blade number 1. The fingers of blade number 2 therefore remove the earth material to a depth indicated as FD, FE, and FF of Fig. 4 respectively. In many instances, the fracturing action extends in under the track-ways A, B, and C respectively down to a depth below the depth of the track-ways A, B, and C respectively.

In actual operation, it has been found that when a bit has been used extensively and is removed from the well bore that the blades numbered 1 are worn substantially by the wearing away of the fingers 40, 41, and 42 of each of the blades number 1, while on the other hand, the fingers such as 91, 92 and 93 of the blade number 2 may not be worn nearly as much because of the fact that these fingers 91, 92, and 93 do not perform as much abrading action as do the fingers 40, 41, and 42 of the number 1 blades. This phenomena is attributed to the fact that the fingers 91, 92, and 93 execute a considerable fracturing action and remove the ridged material of the tracks D, E, and F ahead of the finger so that a considerable amount of this earth material is in this manner removed and in the form of chips or cuttings, and in many instances these chips from the ridges D, E, and F may be an inch or two in arcuate length. The removal of this material by fracture, of course, speeds up the drilling action because it permits a greater percentage of the weight of the drill pipe to be applied to the fingers 40, 41 and 42 of the number 1 blades with a consequent speeding up of the rate of penetration of the bit and the amount of well bore being drilled.

The proposition may thus be stated that the number 1 blades cut the grooves or track-ways A, B, and C and remove the material FA, FB, and FC, some of which occurs by fracture but the majority of which occurs by abrasion. This fracturing by the number 1 blade is accomplished by the upwardly and outwardly radially stepped relationship of the fingers 40, 41, and 42.

On the other hand, the blade number 2 acts as a breaker between the track-ways A, B, and C to fracture out the material and removing the earth formation such as FD, FE, and FF.

The fingers of the blade number 1 and the blade number 2 are off-set radially so that as seen in Fig. 5, a complete coverage of the well bottom is accomplished and the three outer blades such as breaker fingers therefore fracture the earth material to remove the ridges D, E, and F and may be designated as breaker fingers.

It is to be definitely understood however, that the arrangement of the fingers, both radially and in the circumferentially depth relationship, will be varied according to the size of the bit because obviously a bit having a diameter of say 9⅞ inches, which is a standard drilling bit, would be entirely different from the spacing of the fingers on a blade of 3 or 4 inches of the type generally used in slim bore holes or in the drilling of shot holes used in geological or geophysical prospecting.

It is to be understood also that different arrangements of the number 1 and number 2 blades may be provided depending upon the type of the formation which is being drilled. This is desired because brittle or easily fracturable formations would be almost entirely removed by the fingers 40, 41, and 42, leaving little or no material for the number 2 blade and the fingers 91, 92, and 93. On the other hand, tough abrasive formation would be abraded by the number 1 blade fingers 40, 41, and 42 and the number 2 blade fingers 91, 92, and 93 would serve to fracture this material and to break it out of position to speed up the rate of penetration of the formation.

As heretofore indicated, the method of applying the hard metal to the various fingers together with the preparation of the forgings prior to hard facing is such that the abundance of hard metal is assimilated to form a solid uniform deposit having a five bond strength and this has been found to be possible only by the provision of the high ribs such as 55 to form a greater surface to bond the hard material therewith and to provide an abutment for the abundance of hard metal, which is applied by an electric welding process such as the atomic hydrogen process. In this manner, a high temperature is necessary and in this matter obtained to melt the surface of the constant carbide to form a complete bond. When the hard material is applied in this manner, it has been found that the hard metal does not break or crack; is not released from its bond and remains in position so that it is gradually worn or abraded away until the finger is practically worn away.

Broadly, the invention contemplates a means and method of providing a detachable blade bit which will render a maximum of service and which will accomplish the speedy drilling of earth formations of different characters.

What is claimed is:

1. A rotary drill bit having at least three cutting blades thereon, each blade having a plurality of downwardly extending cutting fingers thereon, the cutting fingers of each blade being spaced apart, the fingers of each blade being positioned substantially in a radial plane relative to the turning axis of the bit, the lower ends of the fingers of each blade being stepped upwardly and outwardly, the arrangement being such that a concave stepped bore bottom is formed, said fingers being of L cross section, the base of the L being in a radial plane of the bit and facing in the cutting direction, the side of the L being on the outside of the groove cut by the finger to provide an elongated wearing surface and afford rigidity to the finger.

2. A bit as in claim 1 wherein the said base and side of each finger has applied thereto a coating of hard metal to abrade the earth formation.

3. A bit as in claim 1 wherein the said sides of the fingers increase in length for successive outwardly positioned fingers to provide increased wearing surface to compensate for increased finger travel at successively greater radii.

4. A bit as in claim 1 and further including a projection on each finger disposed upwardly from the cutting edge for supporting thereon a coating of hard metal.

5. A rotary drill bit having at least three blades thereon, these including at least two cutting blades and at least one chipping blade, each blade having a plurality of down-

wardly extending cutting fingers thereon, the cutting fingers of each blade being spaced apart, the lower ends of the fingers of each blade being stepped upwardly and outwardly, the arrangement being such that a concave stepped bore bottom is formed, the respective fingers of the cutting blades being positioned to track one another to cut grooves in the bore bottom, the fingers of the chipping blade being positioned to chip off ridges remaining between said grooves, the lower extremities of the fingers of the chipping blade being substantially in horizontal alignment with the lower extremities of the fingers which cut the groove located next outwardly of the ridge removed by a chipping finger.

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