

Oct. 23, 1951

C. C. BROWN ET AL
ROTARY DRILL STABILIZER

2,572,307

Filed Sept. 9, 1946

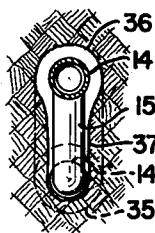
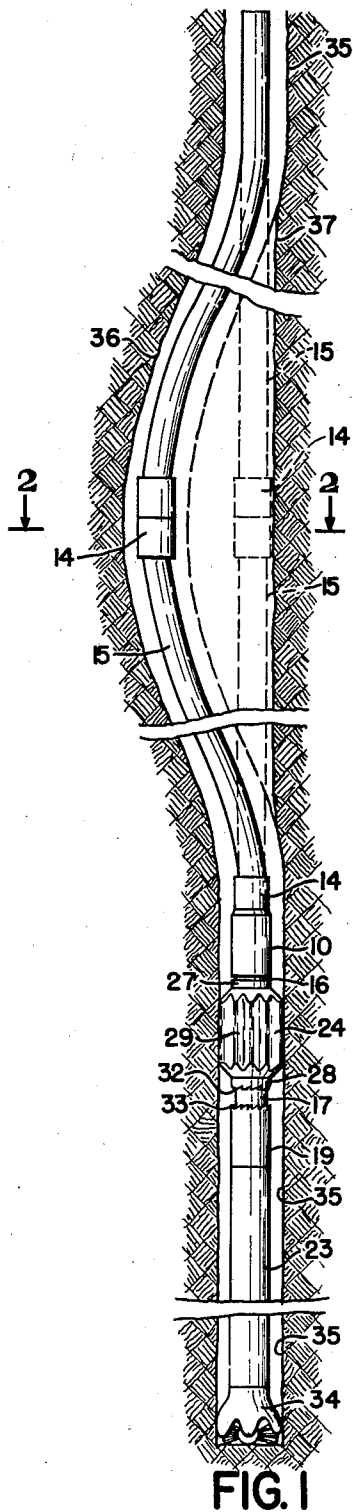


FIG. 2

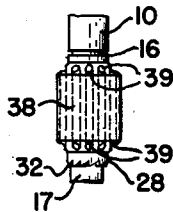


FIG. 5

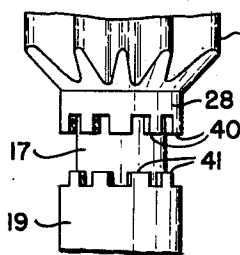


FIG. 6

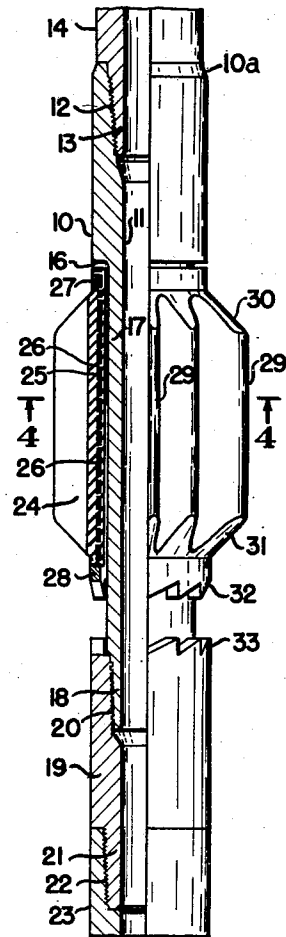


FIG. 3

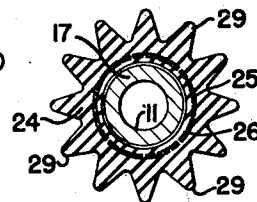


FIG. 4

INVENTOR.
Cicero C. Brown,
Fred F. Waltermire

BY

R. G. G. G.
ATTORNEY

UNITED STATES PATENT OFFICE

2,572,307

ROTARY DRILL STABILIZER

Cicero C. Brown and Fred F. Waltermire,
Houston, Tex.

Application September 9, 1946, Serial No. 695,638

2 Claims. (Cl. 255—28)

1

2

This invention relates to well drilling tools employed in the rotary system of drilling and particularly to drill collar stabilizers.

The drilling string, conventionally employed in rotary drilling, consists of a bit head, the diameter of which determines the diameter of the hole to be drilled; and is normally provided with a short stem of slightly smaller diameter than the over-all diameter of the cutters themselves; a string of hollow drill pipe connected to the bit and stem and generally of much smaller diameter than the bit and stem; and made up of pipe sections joined together by threaded couplings, commonly called tool joints; the outside diameters of which are somewhat larger than that of the drill pipe, but also of substantially lesser diameter than the bit and bit stem; and the usual Kelly joint and swivel attached to the upper end of the string, the kelly passing through the rotary table and being rotated thereby in order to rotate the drilling string and bit. Such drilling strings are extremely flexible and elastic, particularly when they have attained considerable length due to deepening of the well. Due to this flexibility and elasticity, it is generally necessary to add weight to the bit in order to keep the bit in contact with the earth formation to enable it to drill ahead as it is rotated from the top of the well. To increase the weight of the bit, a section of pipe, commonly termed a drill collar, is normally interposed between the upper end of the bit stem and the first section of the drill pipe. Such drill collars are generally of the same outside diameter as the bit stem and may vary in length very considerably, depending primarily upon the depth of the well at a particular time. These drill collars may comprise a single section of pipe or several sections, depending upon the length desired. For the purposes of this description the bit, bit stem and drill collars, together, are sometimes herein referred to as the bit section.

Although the employment of drill collars helps to stabilize the action of the drill bit; nevertheless, because its diameter must normally be less than the over-all diameter of the bit and of the hole being drilled thereby, a substantial degree of clearance necessarily results between the outside of the drill collar and the wall of the well, with the result that some degree of eccentricity or gyration of the upper end particularly of the drill collar occurs during drilling and frequently results in the drilling of crooked holes; and cavitation in the sides of the bore hole where the upper end of the drill collar strikes the wall

under the eccentric or gyratory action mentioned.

A further difficulty which frequently occurs, particularly in drilling deep wells with rotary drill strings of the type described, arises from the combination of the gyratory action of the bit section, the varying hardness of the formations being drilled, the flexibility and elasticity of the drill string, the rotation thereof, and improper application of the weight on the bit. This combination of conditions frequently causes the bit to change direction and depart from the true vertical. Often this diversion in direction is continuous and the well bore will be drilled at a substantial angle to the vertical such that, when this condition is discovered, the drill string must be withdrawn to the point of departure of the original bore hole from the vertical and by the use of suitable well known drilling tools, the well must be redrilled to straighten out the hole. On the other hand, the deviation from the vertical may be only temporary and the bit may, either by control of the drilling operations or of its own accord, return to the original vertical direction after a relatively short length of hole has been drilled. The common result of such a temporary deviation is a lateral bend in the bore hole to which the flexible drill string will generally accommodate itself without undue difficulty. However, due to the flexibility and elasticity of the drill string, the section of the drill string passing around such a curved portion of the hole, since it is normally under a substantial degree of tension, will engage in a whipping action laterally relative to the vertical axis of the bore hole and this action will cause the section of the drill pipe and any tool joint thereon at this point to cut a vertical slot in the side of the formation along the curved portion of the bore hole until it attains a lateral depth at which the drill string may assume its substantially true vertical position throughout this section of the bore hole. The diameter of such a slot is normally approximately that of the diameter of any tool joints on the section of the drill pipe which engages in this cutting action, and generally tapers outwardly towards its opposite ends where it merges with the straight sections of the bore hole. The slot thus cut is commonly called in the industry a "key seat" and is a very common occurrence, particularly in the drilling of deep wells, and its presence is normally not apparent to the driller until he attempts to withdraw the drill string from the well.

When a drill string has cut such a key seat along a bore hole, it will be seen that its small-

est diameter, being little greater than that of the tool joint, will be substantially less than that of the drill collar and bit. Therefore, when it becomes necessary to withdraw the drill string from the well for any reason, such as for the replacement of the bit, the larger diameter drill collar will not be able to pass through the key seat and since withdrawal of the drill string from the well is normally done at relatively high speed, the string may thus become stuck in the key seat and cause the attendant difficulties resulting from such an accident. It is possible, however, that the presence of such a key seat may become known to the driller through the actions of the drill and by carefully withdrawing the drill string, while rotating it, it may be possible to work the drill string around through the curved portion of the drill hole and avoid sticking the drill string in the manner described. However, this is a relatively fortuitous circumstance, since the more common situation is that the presence of a key seat is not initially discovered until the drill collar has become stuck.

Whenever the bit section becomes stuck in a key seat or for other reasons, various expedients may be employed in an effort to release them. For example, a quantity of oil may be pumped down the drill string and up around the outside of the bit section in an effort to provide a degree of lubrication which will effect its release. These expedients generally take time to effectuate, even if they prove successful. During such time mud circulation is generally continued in order to prevent settling of cuttings and sloughing of the material lining the bore hole which would otherwise aggravate the difficulty. However, rotation of the drill during this period cannot generally be continued due to the danger of twist-offs and the inability to rotate the drill string may aggravate the conditions causing sticking despite the continuation of mud circulation.

Once it becomes evident that the bit section cannot be released by way of the conventional expedients, it then becomes necessary to break the drill stem, preferably at a point as close as possible to the point at which the drill is stuck, so that the greatest possible length of drill string may be withdrawn from the well, leaving a minimum amount of equipment to be recovered by conventional fishing operations. This breaking of the drill string may be accomplished by reversing the direction of rotation of the rotary table to unscrew the drill stem or by shooting off the drill stem with explosives placed as near as possible to the point of sticking. However, although some degree of control may be exercised as to the point at which the drill string will unscrew or the shot may be placed, the results are uncertain, at best, particularly since such operations are generally a matter of last resort after all other expedients designed to release the drill have been tried without success. During the time required to exhaust all other expedients, the bore hole above the original point of sticking may be damaged or otherwise so affected that it may no longer be possible to get close to the sticking point with the final breaking operations and much greater portions of the drill string must then be left in the hole for removal by fishing or other operations conventionally employed to clear the bore hole.

It is a principal object of this invention, therefore, to provide a tool for rotary drilling which will obviate or eliminate one or more of the dif-

ficulties, such as those described above, which are commonly encountered in rotary drilling.

Other important objects of this invention are to provide a tool for stabilizing the drill collar to reduce the eccentric or gyratory motion thereof to a minimum; to aid in releasing the drill string when it has become stuck in a key seat or other obstruction in the bore hole; and in cases where permanent sticking of the bit section has occurred, to effect a break in the drill string so as to recover the maximum length of the drill string leaving a relatively minor portion to be recovered by subsequent fishing operations.

Other objects of this invention are to provide a rotary drilling tool which is adapted to be inserted in the drilling string adjacent a drill collar and which is provided with a longitudinally slidable and rotatable section which functions as a stabilizer for the drill collar while, at the same time, permitting a degree of longitudinal and rotational movement of the drill string relative thereto; and which is provided with a clutch mechanism by means of which a controlled breaking of the drill string may be effected if desired.

Other and more specific objects of this invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate useful embodiments in accordance with this invention.

In the drawings:

Fig. 1 is a partly diagrammatic view of a portion of a bore hole illustrating the position and form of a key seat in such a bore hole and showing the position of the drill string, including a tool in accordance with this invention, in position in the bore hole;

Fig. 2 is a cross-section taken along line 2-2 of Fig. 1;

Fig. 3 is an elevational view, partly in section, of a tool in accordance with one embodiment of this invention;

Fig. 4 is a cross-section taken along the line 4-4 of Fig. 3;

Fig. 5 is a view of a portion of the tool in accordance with another embodiment of this invention.

Fig. 6 is a view of a portion of the tool in accordance with still another embodiment of this invention.

Referring to the drawings and to Figs. 3 and 4 in particular, which illustrate one useful embodiment in accordance with this invention, the device consists of a generally tubular body member 10 having a bore 11 and provided with an internally threaded box 12, adapted for connection to the threaded pin 13 of a tool joint 14, which is a part of a conventional drill stem 15 (Fig. 1), the bore 11 of the device being in general alignment with the bore of the tool joint and its connected drill stem. The diameter of body 10 is preferably made equal to or slightly greater than that of tool joint 14, the upper end of body 10 being tapered at 10a to the diameter of the tool joint. Beginning at a point spaced from the upper end of body 10, the exterior of the body is reduced in diameter throughout the remainder of its length, forming a shoulder 16 at an intermediate point along body 10. The portion of reduced diameter of the body, termed the mandrel, is designated by the numeral 17, and at its lower end is provided with a tapered threaded pin 18 for at-

tachment thereto of a tubular sub 19 having a complementary threaded box 20 for reception of pin 18. The lower end of sub 19 is provided with a threaded pin 21, which is adapted for connection into a box 22 of a conventional drill collar 23. The outside diameter of sub 19 is generally made the same as that of drill collar 23 and both are therefore, substantially larger in diameter than tool joint 14 and body 10. Slidably mounted on mandrel 17 is a generally cylindrical sleeve, termed a stabilizer 24, constructed of Duprene, rubber, or other resilient plastic material which is preferably resistant to the action of oil and other well fluids. Stabilizer 24 is preferably molded about a metal reinforcing sleeve 25, which forms a core for the stabilizer, and is provided with a plurality of perforations 26 for assistance in anchoring the plastic material thereto. Reinforcing sleeve 25 is provided at its upper and lower ends, which extend beyond the ends of the body of plastic material attached thereto, with outwardly extending generally annular flanges 27 and 28, respectively, the outer diameters of which are substantially equal to that of sub 19. With this reinforcing arrangement, stabilizer 24 becomes a relatively rigid member so far as resistance to longitudinal pressure is concerned. The exterior surface of stabilizer 24 is preferably formed in molding to provide a series of uniformly spaced longitudinal ribs 29 thereon which extend radially outwardly from the periphery of the stabilizer. The radial length of ribs 29 is preferably such that the diameter of a circle encompassing the outer edges thereof which will be greater than that of the drill collar and sub 19, and which will be almost equal to the diameter of the bore hole, so that the stabilizer will offer no appreciable resistance to the movement of the drill string in the bore hole under ordinary conditions. The upper and lower ends of these ribs are preferably tapered forming generally conical surfaces 30 and 31 about the upper and lower ends of the stabilizer. The lower edge of flange 28 is provided with a circularly arranged set of teeth 32, which are adapted for engagement with complementary teeth 33, arranged on the upper edge of sub 19. The teeth are so formed, that when these elements are in contact, the teeth will become engaged only when sub 19 and the drill stem, to which it is attached, are rotated in the counter-clockwise direction, that is counter to the direction of rotation for normal drilling. The over-all length of stabilizer 24, including teeth 32 and flange 27, is made less than the length of mandrel 17 between shoulder 16 and the upper edges of teeth 33 of the sub, whereby a degree of longitudinal movement of stabilizer 24 on mandrel 17 may occur. A suitable degree of clearance is also provided between the inner surface of stabilizer 24 and the outer surface of mandrel 17 to provide free relative rotational and longitudinal movement between these members. Shoulder 16 and the upper edge of sub 19 form stop means to limit the longitudinal movement of stabilizer 24 relative to the drill string.

The device of this invention is employed in rotary drilling in the following manner:

The tool of this invention is inserted in a drill string between the lower end of drill stem 15 and the upper end of drill collar 23, the latter having a conventional bit 34 attached to the lower end thereof. As drilling proceeds, cutting the bore hole 35 with a diameter substantially

the same as that of the cutting edges of the bit, the tool will move downwardly through the bore hole following the bit. Stabilizer 24 will act to stabilize the bit section, since the ribs 29 thereon will bridge the annular space between the wall of the bore hole and the outside of the drill collar and form a type of sleeve bearing for the upper end of the drill collar which will, therefore, reduce the tendency of the upper end of the drill collar to engage in any eccentric or gyratory movement. When made of resilient material, as described, stabilizer 24 will also absorb the shock of any such movement against the wall of the well bore; the ribbed configuration affording a degree of resilient flexing under such movement, and this will further aid in preventing the drill collar from digging into the wall of the well bore to cause cavitation or sloughing of the wall material into the well. The grooves between ribs 29 will serve as passageways to allow the drilling fluid, normally employed in rotary drilling, to flow past stabilizer 24 in its passage from the bit outlets back to the top of the well through the annular space between the drill stem and the wall of the bore hole. The velocity of flow of the drilling fluid past the stabilizer will normally force it upwardly toward shoulder 16 on body 10 and thereby maintain clearance between teeth 32 and 33. No difficulty will result, however, even if the teeth are in contact, so long as the drill string is being rotated in the normal or clockwise direction. In this event, the teeth 33 on sub 19 will merely roll under and past teeth 32. Inter-locking of the teeth will be effected in the manner described hereinafter.

Should the bit section become stuck in the bore hole, as may often occur, so that it cannot be withdrawn from the well without placing undue strain on the drill string, the slidable arrangement of stabilizer 24 on mandrel 17 may be utilized to employ the tool as a set of jars to free the bit section. This may be accomplished by applying an upward pull on the drill stem by means of the conventional draw works (not shown), at the top of the well until the drill stem, because of its natural elasticity, is in increased tension. Then the drill string is quickly released and then caught after a short interval. These actions will transmit an energy wave down the drill stem and produce a sharp impact between shoulder 16 of body 10 and the upper edge of flange 27. This will produce a jarring effect on the bit section, particularly since it is relatively close to the point of impact, and will loosen the bit section. This jarring action may be repeated as often as necessary to free the bit.

When conditions in the bore hole become such as will normally cause the bit to become stuck, whether it be an unusual degree of settling of cuttings, sloughing of material from the wall of the bore hole, the presence of key seats or other obstructions, stabilizer 24, since it is the portion of the drill string, other than the bit itself, having the largest diameter, will normally become stuck first in any obstruction which would not pass the bit section, and this will occur generally before the bit section itself becomes stuck too tightly to respond to rotation of the drill stem. Rotation of the bit section may, therefore, be continued by means of this tool while operations are conducted to free the drill string, as by effecting the jarring action described above.

When a key seat forms the principal obstruction to the removal of the drill string, stabilizer

24 will be the portion which will first become stuck therein as the drilling string is drawn upwardly therethrough. When this occurs, the tools may often be jarred loose in the manner previously described and the presence of a key seat being thus disclosed, it then becomes possible for the driller, by carefully controlling the rate of withdrawal of the drill string and by continuing its rotation, to work the string around the key seat through the bore hole proper and thus withdraw the tools. Here again the presence of the stabilizer 24 in the drill string, which permits the driller to maintain relatively free rotation of the string, is of great assistance in these removal operations.

In a case, however, where stabilizer 24 becomes so stuck in the bore hole that the tools cannot be released by any of the previously mentioned expedients and it then becomes necessary to break the drill string, the tool in accordance with this invention may be employed to effect the break in the following manner:

An upward pull will be applied through the draw works to the upper end of the drill string which will draw the lower end thereof, comprising mandrel 17, sub 19, drill collar 23 and bit 34, upwardly through stabilizer 24 until teeth 33 on sub 19 engage teeth 32 on the lower end of stabilizer 24. The rotary table is then rotated in the counter-clockwise direction to similarly rotate the drill string. This will lock the engaging teeth together and produce a clutching action of stabilizer 24 on the lower end of the drill string, so that upon continuation of the counter-rotation of the drilling string, the string can be readily backed-off or unscrewed from the portion which is thus being held stationary. By suitable control of the tension applied to the upper end of the drill string, in a manner well understood in the drilling art, the drill stem can generally be caused to back-off at a point very close to the portion thus held stationary, with the result that maximum lengths of the drill string can thus be readily recovered without serious damage, generally leaving only the stabilizing tool and bit section to be removed by the subsequent fishing or other well known operation employed to clear the hole.

Such fishing operations will also be substantially aided by the form of the stabilizer 24. Where the latter is constructed of relatively soft plastic material, whether or not the rib-type configuration is employed, it becomes relatively easy, when a conventional reaming cutter is run into the well, to ream off the relatively soft material composing the stabilizer to the point where conventional hollow fishing tools may easily pass over the outside of the remainder of stabilizer 24 to reach and grasp the drill collar.

Instead of constructing stabilizer 24 of resilient or plastic material, as described, stabilizer 24 may be constructed of steel or other metal having ribbed configuration similar to that described. In this case, the stabilizer will retain the stabilizing characteristics previously described and may have a further advantage in that the ribs may serve as milling teeth which may be employed during the application of the described jarring action to cut away many of the types of obstructions which would normally prevent the removal of the drill string.

Fig. 5 illustrates another form of stabilizer which may be successfully employed with the tool of this invention in place of stabilizer 24. In this embodiment a stabilizer 38, which may be constructed of resilient or plastic materials, of

the type previously described or of steel or other metals, as may be desired, is slidably mounted on mandrel 17. Instead of an external ribbed configuration, as in the previously described embodiment, stabilizer 38 is provided with a smooth exterior and a plurality of circumferentially spaced longitudinal passageways 39, which extend through the body of the material between the inner and outer surfaces thereof for passage of drilling fluid therethrough. Since much of the material forming the body of stabilizer 38 will be removed in providing passageways 39, this embodiment, even when constructed of metal, can be ground or reamed off when necessary without undue difficulty. In substantially all other respects, this embodiment will function just as that previously described and will retain the advantageous features thereof.

Fig. 6 illustrates still another embodiment in accordance with this invention in which flange 28 and the upper end of sub 19 are provided with teeth elements 40 and 41, respectively, which are of substantially square shape or of other suitable configuration such that, when brought into inter-engagement by an upward pull on the drill string, clutching engagement of stabilizer 24 with the drill string will be effected, irrespective of the direction of rotation of the drill string. Such an embodiment is particularly useful in connection with the milling operation described above. In this operation by clutching the parts together while rotating slowly in the normal or clockwise direction, a rotational component may be imparted to the reciprocatory movement of stabilizer 24 which will aid the milling operation. This embodiment may also be employed for the unscrewing or backing-off operation previously described, when necessary or desirable, by rotating the drilling string in the counter-clockwise or anti-normal direction while the teeth are held in inter-engagement by an upward pull applied to the drill string.

It will be understood that the dimensions of the parts of the device in accordance with this invention may be varied depending primarily on the size of the drill bit and drill collars employed. The degree of longitudinal movement of the stabilizer on mandrel 17 is likewise variable but, in general, only a few inches of such movement is all that is necessary. Merely by way of illustration, in the case of a 12-inch stabilizer, the degree of longitudinal movement may be about eighteen to twenty-four inches to enable the device to successfully accomplish its several functions.

It will be understood that while the device in accordance with this invention is preferably employed by inserting it in a drill string immediately adjacent the upper end of the bit section, it may be employed successfully by inserting it between sections of a drill collar, and in some cases may be spaced above the end of the uppermost drill collar.

Various alterations and changes may be made in the details of the device in accordance with this invention within the spirit of this invention and without departing from the scope of the appended claims.

What we claim and desire to secure by Letters Patent is:

1. A drill collar stabilizer comprising, a tubular body member adapted to be inserted in a drill string adjacent a drill collar, said body member having a portion of reduced diameter intermediate its ends to form an upper stop member on said

body member, a tubular sub connected to the lower end of said body forming a lower stop member, a tubular sleeve member rotatably mounted on said portion of reduced diameter and slidable thereon between said stop members, cooperating clutch means arranged between the lower end of said sleeve member and the lower one of said stop members engageable only upon upward movement of said tubular body relative to said sleeve member to effect clutching engagement thereof, a plurality of angularly spaced vertically extending ribs on the exterior of said sleeve member, the external diameter of said sleeve member including said ribs being greater than that of said drill collar, said tubular sleeve member including said ribs comprising a generally tubular body constructed of resilient rubber-like material mounted upon a tubular metallic core, the ends of which extend beyond the ends of said body of resilient material, laterally extending flanges on the opposite ends of said core, the upper one of said flanges cooperating with the upper one of said stop members for effecting jarring impacts therebetween, and the lower one of said flanges carrying one of said clutch members.

2. A rotary drill stabilizer comprising, a tubular body insertible in a drill string, a first stop member mounted at an intermediate point on said body, an enlargement forming a second stop

member connected to said body below said first stop member, a tubular sleeve member rotatably and slidably mounted on said body between said stop members, said sleeve member comprising a tubular metallic core, laterally extending flanges on the opposite ends of said core, a generally tubular member constructed of resilient rubber-like material mounted on said core between said flanges and having a plurality of angularly spaced longitudinal ribs projecting radially from the exterior surface thereof, and cooperating clutch elements mounted on the lower one of said flanges and the adjacent stop member engageable upon upward movement of said tubular body relative to said sleeve member.

CICERO C. BROWN.
FRED F. WALTERMIRE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,072,320	Thomas	Mar. 2, 1937
2,166,937	Bettis	July 25, 1939
2,177,300	Kellegrew	Oct. 24, 1939
2,323,027	Gerstenkorn	June 29, 1943