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F. HONIG

DIE FOR WIRE DRAWING, ETC

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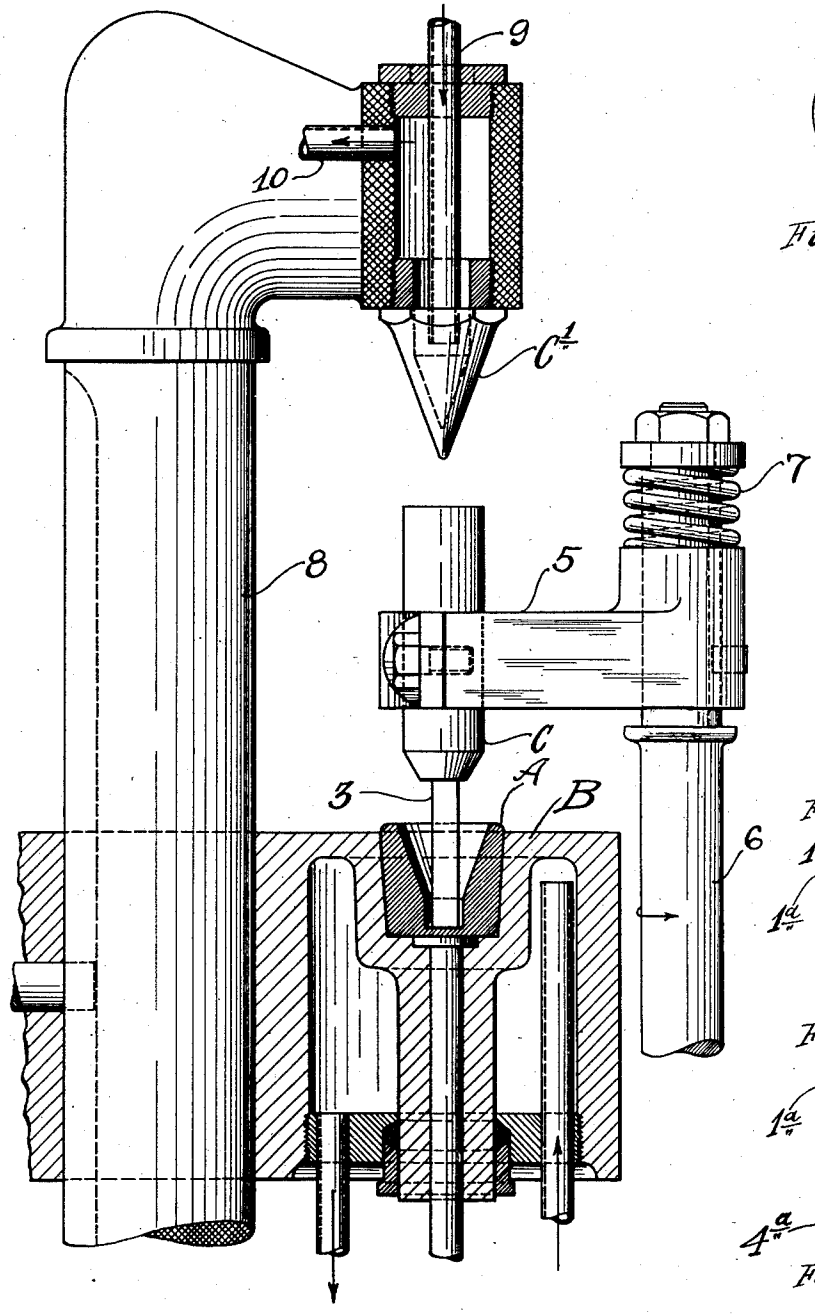


Fig. 1

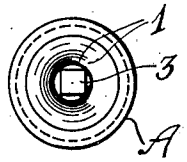


Fig. 2

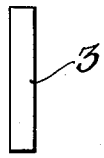


Fig. 3

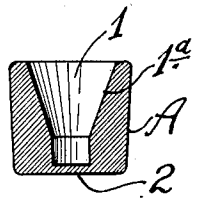


Fig. 4

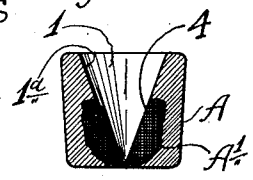


Fig. 5

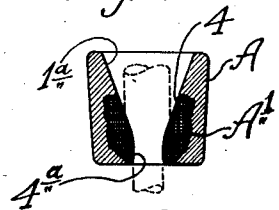


Fig. 6

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UNITED STATES PATENT OFFICE.

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DIE FOR WIRE DRAWING, ETC.

Original application filed June 9, 1921, Serial No. 476,115. Divided and this application filed October 16, 1924. Serial No. 743,968.

This invention relates particularly to dies for wire-drawing purposes and to a method of manufacturing the same. The invention is applicable, however, to dies for various purposes.

The primary object is to provide a die having greatly improved wear-resisting qualities. A further object is to provide an improved method of manufacturing dies, enabling a die of long life to be manufactured quite cheaply.

In accordance with this invention, as preferably practiced, a composite die is formed which possesses a body of great strength, preferably steel, and which possesses a wear-resisting operative portion of great hardness, the wear-resisting portion being preferably tungsten containing a small percentage of carbon, the operative portion being subjected to special treatment in the process of manufacture.

The method of practicing the invention is illustrated in the accompanying drawing, in which—

Fig. 1 represents brokenly and partly in section apparatus adapted for use in the manufacture of the improved die; Fig. 2 shows a plan view of a die-body, or matrix, having inserted therein a tungsten body, preparatory to a consolidating operation; Fig. 3, an elevational view of the tungsten body; Fig. 4, a sectional view of the die-body, or matrix; Fig. 5, a sectional view of the die after the tungsten body has been consolidated with the matrix, and Fig. 6, a sectional view showing the completed die, the dotted lines illustrating the drawing of a rod or wire through the die.

As shown in Fig. 6, the die comprises a strong metal body A, which preferably is of steel, and a tungsten body insert A′, which preferably comprises tungsten and a hardening agent, such as carbon, the tungsten body being consolidated with the matrix in the process of manufacture.

In the preferred method of manufacture, the body, or matrix, A is first formed in the shape shown in Fig. 4, being in approximately cylindrical form and provided with a bore, or recess, 1 which has a tapered, or flaring, end portion 1^a at one end of the block. At the other end of the bore 1, the block is preferably provided with a thin end wall 2.

A bar of tungsten 3 is introduced into the bore 1; the body A of the die is introduced into a water-cooled cup-shaped terminal, or electrode, B; another electrode C is applied to the upper end of the piece of tungsten; and, by means of electric current, the tungsten bar is melted so as to fill, or partially fill, the lower portion of the cup-shaped body A. After the tungsten body has been melted, the water-cooled pointed tool C′ is introduced and employed to cool and mold the tungsten body. During the period of solidification of the tungsten, it is subjected to pressure which is increased as the solidification progresses. The action of cooling and molding the tungsten body has the result of preventing the formation of the ordinary characteristic crystalline agglomeration of the particles. The shaping is largely effected during the period of solidification and before the tungsten body has assumed its final, very hard condition.

The tungsten body employed preferably comprises tungsten and carbon, the latter serving as a hardening agent. The preferred method of producing the tungsten billet which is employed is to heat tungsten trioxide in an oxidizing atmosphere, such as air, for a period of about twenty minutes, at about 1000° C. to 1200° C.; then to reduce the oxide so produced in a current of dry hydrogen at about 1000° C. to 1100° C. into a coarse crystalline tungsten powder; and then to mix the tungsten powder and lamp black and compress the mixture into a billet. The lamp black will serve as a binding material. The billet may be conveniently formed, for example, in a length of about 6″ and a cross section of about ¼″ square, subjected to pressure of about three thousand pounds per square inch. The billet so produced is very fragile. It is heated in a current of neutral atmosphere for a period of about twenty minutes up to about 1200° C. after which it may be cut, by means of a saw or grinding stone into four bars of 1½″ in length. Such a billet will supply an ample amount of the tungsten body for use in a medium size or a large size die.

In forming the billet as above described,

it is preferred to employ about 2% by weight of carbon in the form of lamp black. The percentage may be considerably lower, but rarely should go as high as 3%. It may be stated here that 2% carbon by weight is sufficient to give a large volume of carbon, especially when the carbon is used in the form of lamp black.

It will be understood by those skilled in the art that the melting of the tungsten and the operation of consolidating the tungsten body with the matrix should be effected in a non-oxidizing atmosphere, as, for example, a hydrogen atmosphere. Any suitable provision may be employed to enable this to be accomplished, no special provision being here shown. The operation of melting the tungsten and consolidating the tungsten body with the matrix results in the formation of a high percentage of carbides, especially at and near the chilled surface 4. It is believed that the carbon is deposited and held more and more in solid solution as the depth from the surface increases. Whatever may be the correct explanation, the result of the complete process is to produce an exceedingly hard wear surface for the die.

After the die has been produced in the form shown in Fig. 5, a perforation 4^a is drilled through the center of the block, the upper end of this perforation merging with the conical surface 4 formed by the pointed tool. After the drilling operation, which cannot be performed by ordinary drilling methods, but must be accomplished by the method used in drilling diamond dies, the surface of the bore is lapped, ground or made smooth in any desired manner. It is preferred, after the drilling operation, to subject the wear surface of the die to a mechanical operation, as by inserting a suitable tool and applying heavy pressure and effecting relative rotation between the tool and the die during this operation. The inner surface of the die preferably is subjected to a charging operation, also, in which operation graphite, or other solid lubricating material, such as soap-stone, is caused to fill the pores in the metal at the operative surface of the die. Preferably, this is effected by introducing graphite and grinding it into the pores of the surface by means of a tool hardened and ground to fit the form of the interior surface of the die. This is effected under heavy pressure, the pressure being preferably higher than that to which the die would be exposed when the wire is drawn therethrough. The high pressure serves to charge the minute openings of the tungsten or steel, as the case may be, with the solid lubricant, thus insuring an exceedingly smooth wear surface and an unbroken film of lubricating material at such surface. In the use of the die, additional lubricant is introduced, of course, as the wire-drawing operation proceeds. It may be added that tungsten has a great affinity for carbon, and where graphite, or carbon, is used as a solid lubricant during a wire-drawing operation, the die tends to keep its surface charged with a sufficient carbon content to maintain the best wearing surface.

It may be stated that if the tungsten body has been melted, and worked into virtually integral formation with the steel cup by heavy pressure, during which process the body is chilled, as well as condensed, it possesses a structure capable, in the highest degree, of resisting wear and at the same time capable of withstanding exceedingly high pressure, it being noted that the tungsten is backed, bound or encased by the steel shell which possesses a very high tensile strength. In this connection, it may be stated that the pressures produced in wire-drawing operations sometimes reach the enormous amount of 500,000 pounds per square inch. Accordingly, the life of the ordinary steel die, or the highest grade steel alloy die, is comparatively short. The improved die possesses the requisite strength, increased hardness and superior wear-resisting properties.

While it is preferred to make the working surface of the die of tungsten, it may be stated that steel, or suitable steel alloy, may itself be subjected to charging and working with highly beneficial results. For example, the die may be composed wholly of tungsten and steel, which may be reduced to a molten condition while confined in a suitable mold, and then subjected to a chilling, pressing and mechanical working operation, as by means of a pointed tool, in much the manner described. This will result in increasing the density, hardening to a certain extent, and generally improving the wear-resisting qualities of the die.

Moreover, the method of charging the wear-surface of the die with solid lubricant, such as graphite, which has been described, may be applied to ordinary dies with beneficial results. For example, steel dies may be subjected to an operation of charging the pores of their wear surfaces with a solid lubricant by pressing the lubricant into the pores under intense pressure, at the same time turning or operating the tool so as to, in effect, grind the lubricant into the pores and to some extent the wear surface of the die. In this manner, dies may be produced which will permit a wire-drawing operation to be performed at a speed of about fifty per cent greater than is now employed, without injury to the dies, and with prolonged life for the dies. It is quite possible that in the use of the die enough heat is developed at the reducing point to cause a progressive

formation of, or constant renewal of, a carbide surface. This may be a possible explanation of the improved wearing qualities resulting from the use of graphite as a solid lubricant ground into the pores at the wear-surface of the die, it being noted that graphite gives a markedly better result for this purpose than could be obtained from any other form of solid lubricant, such as soap-stone. When the method first described herein is followed in the manufacture of the die, the efficiency of the die over the best-known metal dies may be several times greater.

Any suitable apparatus may be employed for producing the improved die provided with the tungsten body insert. In the device illustrated in the drawing, the electrode C may be a carbon electrode carried by an arm 5 which is keyed to the upper end of a rod 6 and backed by a spring 7 adapted to yieldingly press the electrode C against the upper end of the tungsten body 3 at the beginning of the melting operation. During the melting operation, the body 3 tends to collapse, or shrink, away from the electrode, and an arc is established by means of which the melting operation is completed, the molten tungsten body being received in the matrix. After this, the arm 5 is swung out of the way, and the water-cooled, pointed tool C′ is drawn downwardly to effect, under suitable pressure, the molding of the tungsten body and its consolidation with the metal matrix. As stated, the matrix preferably is of steel, but may be of iron, either cast or wrought iron. The tool C′ is shown mounted upon a plunger 8. The tool is hollow to provide a compartment for water, which is supplied through a tube 9, the heated water passing out through the tube 10.

It should be stated further that in the manufacture of the die, the heat of the electric current and also the heat of the molten tungsten body serves to melt or soften a portion of the steel supporting body of the die and the tungsten becomes thoroughly welded to the steel. At the junction between the tungsten and the steel, an alloy is formed. The tungsten penetrates the steel to a certain extent, and, conversely, the steel penetrates the tungsten to a certain extent. The working surface of the tungsten body is believed, however, to comprise carbides of tungsten.

While the invention possesses great value in connection with dies for wire-drawing purposes, it is evident that the invention may be applied to dies for other purposes. For example, a steel supporting body having a shell or wear surface of tungsten applied thereto may be produced substantially in the manner described. For some purpose, it may be desirable to produce dies for punching operations in this manner. Thus, the female die may be lined with a tungsten body and the male die may be encased in the tungsten shell, so that the operative surfaces are of tungsten, while the bodies of the dies are steel, giving the necessary strength and also desirable cheapness. Any suitable metal or alloy of sufficient strength may be used as an equivalent of the steel in the supporting block.

While it is preferred to employ carbon in some form as a hardening agent for the tungsten, it may be stated that any suitable practical equivalent may be employed, such as boron, silicon, or a mixture of carbon boron or silicon, or any two of them. Obviously these hardening agents, or one of them, may be introduced into the tungsten by any suitable method known to metallurgy. On account of the abundance of carbon and the comparative ease with which it can be combined with tungsten, as well as on account of the very great hardness of the tungsten carbide, it is preferred to employ carbon in some form as the hardening agent. As a further illustration, the matrix A may itself be composed of iron and carbon, or iron, carbon and silicon, and the hardening agents may, during the process of melting a bar of pure tungsten in the matrix and consolidating it with the matrix, become diffused in the tungsten and form the tungsten compounds which give the high wear resistance qualities to the die. Where several hardening agents are employed, the carbides, or tungsten compounds, may be correspondingly complex.

In the process of forming the improved tungsten die, it may, perhaps, be more accurately said that the tungsten, containing a percentage of carbon, is melted or rendered sufficiently fluid to fill or conform to the matrix in the steel block and that by the use of the water-cooled pointed tool, applied with suitable and preferably continued pressure, the surface is chilled while the pressure is applied. Since tungsten melts at an extremely high temperature (about 3400° C., see Smithsonian Physical Tables, 1921) and carbon sublimes at about 3500° C. (idem), it is altogether probable that tungsten carbides, or carbide, are formed, and that the chilling fixes these carbides at and near the chilled surface. In any event the metal at the surface is extremely hard (scratching anything except diamond), and the hardness decreases from the surface inwardly. It may be added that a small percentage of carbon will suffice to give to the tungsten the desired characteristics. While it is believed that the carbon is fixed in a combined state, or as a carbide, at and near the chilled surface and is perhaps deposited and held more and more in solid solution as the depth from the surface increases, it is unnecessary to commit oneself definitely to any theory of expla-

nation of the improved result. In any event, the carbon serves as a hardening agent, and this is particularly true at or near the chilled surface of the tungsten body.

The present application constitutes a division of my application No. 476,115, filed June 9, 1921, which describes and claims an improved method of manufacturing dies. The claims of the present application are directed to the improved die.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, but the appended claims should be construed as broadly as permissible in view of the prior art.

What I regard as new, and desire to secure by Letters Patent, is:

1. A die comprising a steel supporting body and a tungsten body containing a hardening agent press-cast onto and consolidated with the supporting body.

2. A die comprising a steel supporting body having a tungsten body containing a small percentage by weight of carbon press-cast onto the supporting body and consolidated therewith, said tungsten body having a chilled surface.

3. A die comprising a steel supporting body having a tungsten body comprising tungsten and a small percentage of a hardening agent press-cast onto the supporting body and consolidated therewith, said tungsten body having a formed, chilled surface produced in the casting operation.

4. A die comprising a steel body and a body comprising tungsten and a small percentage of a hardening agent cast-welded under pressure onto said steel body and consolidated and condensed, said tungsten body having a chilled surface.

5. A die comprising a steel shell and a worked tungsten body containing a hardening agent cast-welded under pressure in said shell, said tungsten body having a chilled surface.

6. A die comprising a steel shell and a tungsten body comprising tungsten and a small percentage by weight of carbon cast-welded in said shell and having a chilled surface formed in the casting operation.

7. A die comprising a supporting body and a cast-press-formed tungsten body comprising tungsten and a small percentage by weight of carbon welded onto said supporting body under pressure accompanied by working, the working surface of said die having a solid lubricant ground into its pores under heavy pressure.

8. A die having a working surface comprising metal and having a solid lubricant ground into its pores under heavy pressure.

9. A die comprising a supporting metal shell and a tungsten body cast-welded under pressure in said shell, said tungsten body containing a hardening agent and having a formed, chilled surface, formed in the casting operation.

10. A die comprising a metal supporting shell provided at one side with a bore having cast-welded therein under pressure a tungsten body containing a hardening agent, said tungsten body having a converging cavity formed under working pressure in the casting operation and affording a wear-surface, said die having also a drilled hole extending from the bottom of said cavity through the bottom wall of the die.

11. A die comprising a steel supporting body and a tungsten body containing hardening agents comprising carbon and silicon press-cast onto and consolidated with said body.

12. A die comprising a steel supporting body and a tungsten body containing hardening agents comprising carbon, silicon and boron consolidated with said supporting body and affording a working surface.

13. A die having a working surface comprising tungsten and a hardening agent combined therewith while the tungsten was in molten condition.

14. A die having a working surface comprising tungsten and hardening means comprising carbon and silicon combined with the tungsten at a temperature near the subliming temperature of carbon with the tungsten in molten condition.

15. A compressed and chilled body of tungsten and hardening agents comprising carbon and silicon combined with the tungsten when the tungsten is in molten condition.

16. A die having a working surface comprising a press-cast body comprising tungsten and hardening agents comprising carbon, silicon and boron combined with the tungsten while the latter was in molten condition.

17. A wire-drawing die having a perforation therethrough provided with a working surface comprising a press-cast body comprising tungsten and hardening agents comprising carbon, silicon and boron combined with the tungsten while the latter was in molten condition.

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