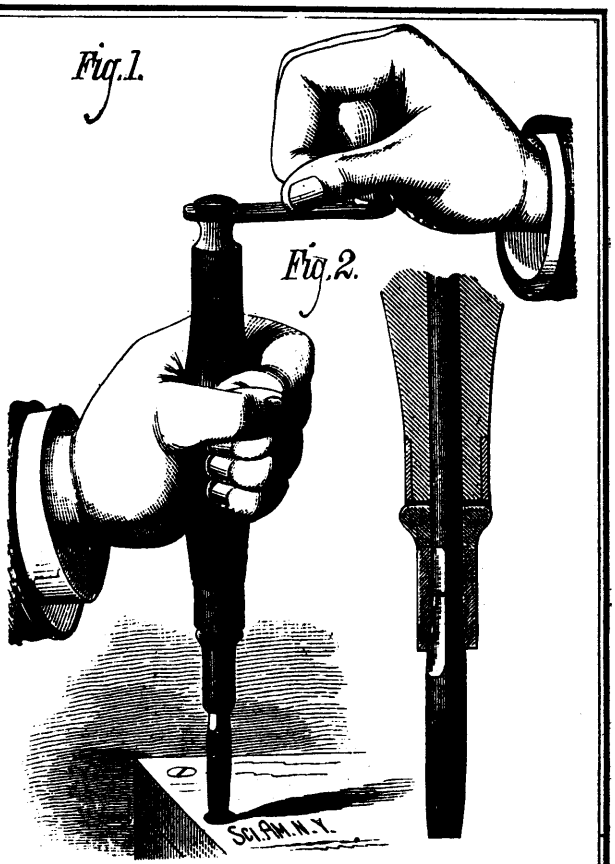
which exerts the greatest influence on the increase of hardness by a certain hardening process is the content of combined carbon in the iron. Iron completely free from carbon is, even after hardening in mercury, as soft as before, and an otherwise pure iron, with at most two-tenths per cent. carbon, does not become very much harder by hardening; but, on the other hand, as the content of carbon increases, the difference in the degree of hardness before and after hardening increases more and more, so that the boundary line between iron and steel lies in general at a content of carbon of about 0·4 per cent., this depending, however, upon the iron's content of certain other substances, which, as we shall soon see, also exercise some influence on the degree of hardness. In the closest connection with the increase of the hardness by hardening stand the raising of the limit of elasticity, and the breaking strain of ultimate tensile strength and the diminution in ductility. Unfortunately the researches that have been carried out regarding these points are not yet numerous enough to enable us with figures to express completely all the changes in these respects which are caused by hardening in iron and steel with different contents of carbon, but sufficient experiments have already been made to give us somewhat satisfactory ideas on this point. A comparison shows that the effect of hardening is in general less in the case of the weld-iron, loose or open in its texture, than in that of the dense or compact ingot-iron; but in proportion as the former even is denser or freer of cinder, hardening has a greater effect upon it, as is shown by a comparison both of the more compact Lesjöfors iron with the other sorts of iron refined in the open hearth, and of the more compact Surahammar with the other sorts of puddled iron. In order to augment considerably the strength of ordinary puddled iron, the French iron-manufacturing company, "La Compagnie de l'Horme," increases the hardening power of water by adding to it sulphuric acid. The cooling effect of water is thereby raised, and thus also its hardening power; but in order to prevent the corrosion and rusting of the iron, it would be advisable to endeavour to attain the same result in some other way, as by the addition of some salt that would have less corrosive action upon the iron. Hitherto we have considered the influence of hardening upon iron, but if we proceed to investigate its action on steel, we find that it is chiefly by an increase in its hardness and a diminution in its ductility greater in the same proportion as the steel is richer in carbon, and the hardening fluid employed is more powerful in its action. At the same time that steel with an increased content of carbon becomes, through a certain hardening, all the harder, it becomes thus at the same time more brittle, and in the closest connection with this is the fact that in the hard steel, rich in carbon, the limit of elasticity is increased by hardening much more than the ultimate tensile strength, so that these in the strongly-hardened hard steel even coincide. Provided the method of hardening is adjusted to the degree of hardness of the steel, so that it is less powerful in the same proportion as the content of carbon in the steel is greater, it may, however, be asserted that the breaking weight is increased by hardening, even in the case of steel; but if the hardening be too strong, the ultimate tensile strength of hard steel is thereby diminished quite rapidly; or the steel breaks in pieces of itself either during the hardening or a short while after. It is, as is well known, on account of this brittleness or deficient ductility that the hardened steel is usually tempered or heated to 200° C. to 300° C., for thereby its ductility is somewhat increased, and its hardness at the same time also diminished. This is the case most of all with the outer layer, which of course is that which it is desired should be hardest, and to avoid this and the trouble and loss of time connected with the process just mentioned, the hardening itself is sometimes instead so modified that its effect is equal to that of a more powerful hardening followed by tempering. For such a method, however, more than common skill and practice are required, and it is therefore comparatively seldom used. For attaining this end there is sometimes used a less powerful hardening fluid, and sometimes a warm instead of a cold fluid, and sometimes the piece is held only a short time in the hardening fluid, and is taken out while it is yet warm in its interior and allowed finally to cool in the air. Further, the material may, for this purpose, be heated more gently, but it must be kept in mind in connection with this that a less heat than a gentle red heat (cherry red) in general does not induce any proper hardening; and, on the other hand, that tool steel cannot in most cases be heated to a higher temperature than that just indicated without running the risk of becoming by hardening quite too brittle. It is thus properly only for soft steel and iron that the degree of heating can be varied to a greater extent, but it holds good specially for the latter, and, above all, for weld-iron, that the temperature must be considerably higher than for hard steel, if the proper action of hardening is to be attained. The more strongly and the longer that the iron or steel after hardening is again heated with slow cool supervening, the more completely are the effects of hardening removed; and care ought, therefore, as is well known, to be taken in tempering; but here we have, however, a good help in the different colours of tempering which follow one after the other. On the appearance of fracture also the hardening has an influence, the grain becoming finer.



ABRAMS' CRANK SCREW DRIVER.

CAN A STEAM PIPE SET FIRE TO WOOD?

At the Crescent Steel Works in this city, a steam pipe two and one-half inches in diameter, carrying 90 to 100 pounds pressure, was laid underground about three years ago, encased in common pine boards about one inch thick. A few days since occasion was had to dig up the pipe, and the whole length of the wooden drain was found to be charred, and apparently burnt, about three-fourths of the thickness of the wood, the other fourth being partially rotted. The whole inside of the drain was turned to charcoal, with here and there spots of white ashes, showing that ignition had actually taken place. It seems probable that if the casing had not been excluded from the air by the earth covering, it would have blazed and been entirely consumed. It is generally believed that a steam pipe cannot set fire to wood, but this case seems to prove the contrary, and it may explain the origin of many mysterious fires. It indicates at least that care should be taken to prevent the close proxmity of easily combustible material to steam pipes carrying a high pressure of steam. The temperature of steam due to a pressure of 100 pounds per square inch is about 337 degrees Fahrenheit.

AN IMPROVED SCREW-DRIVER.—The engraving given herewith represents an improved screw-driver recently patented by Mr. George Abrams, of Philadelphia, Pa. It consists of a handle through which extends a shaft, having on the upper end a crank and upon the lower end a socket for receiving the screw driver bit. With this tool screws may be inserted and removed with much greater facility than with the ordinary form of screw-driver, as the motion is a continuous rotary one instead of intermittent. If desired the screw-driver bit may be removed and a drill or boring tool inserted in its place.