tor apprehends the converſion is sufficiently completed, the fire is ſuffered to go out, and the furnace, with its contents, is left gradually to cool. This may take up ſeveral days : after which the furnace is diſcharged, by taking out the bars of ſteel and the remainder of the charcoal duſt.

There is a manufactory eſtabliſhed in the pariſh of Cramond, about five miles from Edinburgh, in which this method is practiſed with great ſucceſs. Great quanti­ties of ſteel are made there, which we have reaſon to be­lieve is of as excellent a quality as any that can be pro­cured from other countries.

When the charcoal is taken out, it is found as black as before it was introduced into the furnace, unleſs by accident the external air has got admittance. The bars preſerve their exterior form only ; the ſurface fre­quently exhibits a great number of tumors or bliſters, whence they are called *blistered steel.*

The hardneſs of ſteel is much increaſed by temper­ing. This conſiſts in heating it to a red heat, and then plunging it ſuddenly into cold water. If it be al­lowed to cool ſlowly, it still preſerves its ductility ; or if it be heated again after being tempered, it loses its hardneſs, and again becomes ductile. In heating ſteel for tempering it, the moſt remarkable circumſtance is, the different colours it aſſumes, according to the degree of heat it has received. As it is gradually heated, it becomes white, then yellow, orange, purple, violet, and at laſt of a deep blue colour.

According to Reaumur, the ſteel which is moſt heat­ed in tempering is generally the hardeſt. Hence it is believed, that the more violent the heat to which ſteel is expoſed, and the more ſuddenly it is plunged into cold water, the harder the ſteel will be. Rinman, again, has deduced a conclusion directly oppoſite, that the ſteel which is naturally hardeſt demands the leaſt de­gree of heat to temper it. Different methods have been propoſed to determine what degree oſ heat is moſt proper ; but the easieſt method is to take a bar of ſteel, ſo long, that while one end is expoſed to a violent heat, the other may be kept cold. By examining the inter­mediate portions, it may be found what degree of heat has produced the greateſt hardneſs.

By tempering, ſteel is ſaid to increaſe both in bulk and in weight. Reaumur ſays, that a ſmall bar six inches long, six lines broad, and halt an inch thick, was increaſed at leaſt a line in length after being tempered to a reddiſh white colour ; that is, ſuppoſing the dilata­tion proportional in all dimenſions increaſing at the rate of 48 to 49. Iron alſo expands when heated ; but when the heat passes off, it returns to its former dimenſions. That the weight of ſteel is alſo augmented by tempering, has been found by experiment. Rinman ha­ving weighed exactly in an hydroſtatic balance two kinds of fine ſteel made by cementation, and not tem­pered, found their denſity to be to that of water as 7,991 to 1 ; after being tempered, the denſity of the one was 7,553, and that of the other 7,708. Μ. de Morveau took three bars juſt of a ſize to enter a certain caliber 28 lines long, and each side two lines broad; one of the bars was ſoft iron, and the two others were taken from the ſame piece of fine ſteel. In order to commu­nicate an equal degree of heat to each, in an earthen veſſel in the midſt of a wind furnace, the bar of ſoft iron and one of the bars of ſteel were thrown into cold water; the other bar of ſteel was cooled ſlowly over ſome pieces of charcoal at a diſtance from the furnace. The bar of iron and the one of ſteel that was allowed to cool ſlowly paſſed eaſily into the caliber again ; but the bar of tempered ſteel was lengthened almoſt one- ninth of a line.

There is no doubt but tempering changes the grain; that is, the appearance of the texture of a piece of ſteel when broken. This is the mark which is uſually obſerved in judging of the quality of ſteel, or of the tem­pering which ſuits it beſt. The tempered bar is bro­ken in ſeveral places after having received different de­grees of heat in different places. What proves com­pletely the effect of heat upon the grain, at leaſt in ſome kinds of ſteel, is, that a bar of ſteel expoſed to all the intermediate degrees of heat, from the ſmalleſt ſen­ſible heat to a red heat, is found to increaſe in fineneſs of grain from the ſlightly heated to the ſtrongly heated end. The celebrated Rinman has made many experi­ments on the qualities of ſteel expoſed to different de­grees of heat in tempering, but particularly to three kinds, viz. ſteel heated to an obſcure red, to a bright red, and to a red white. Hard brittle ſteel, made by cementation, and heated to an obſcure red and temper­ed, exhibited a fine grain, ſomewhat ſhining, and was of a yellow white colour. When tempered at a bright red heat, the grain was coarſer and more shining ; when tempered at a red white heat, the grain was alſo coarſe and ſhining.

With a view to determine how far ſteel might be improved in its grain by tempering it in different ways, Μ. de Morveau took a bar of bliſtered ſteel, and broke it into four parts nearly of the ſame weight. They were all heated to a red heat in the ſame furnace, and withdrawn from the fire at the ſame inſtant. One of the pieces was left at the side of the furnace to cool in the air, the ſecond was plunged into cold water, the third into oil, and the fourth into mercury. The piece of ſteel that was cooled in the air refilled the hammer a long time before it was broken ; it was necessary to notch it by the file, and even then it was broken with difficulty. It ſhowed in its fracture a grain ſenſibly more fine and more ſhining than it was before. The ſecond piece, which had been plunged into water, broke eaſily : its grain was rather finer than the first, and al­moſt of the ſame white colour. The third piece, which was tempered in oil, appeared very hard when tried by the file ; it was ſcarcely poſſible to break it. Its grain was as fine, but not quite ſo bright, as that which was tem­pered in water. The fourth piece, which was dipped into mercury, was evidently ſuperior to all the rest in the fineneſs and colour of the grain. It broke into many fragments with the first ſtroke of the hammer, the fractures being generally tranſverſe.

Μ. de Morveau was not altogether ſatisfied with theſe experiments, and therefore thought it necessary to repeat them with finer ſteel. He took a bar of ſteel two lines ſquare, ſuch as is uſed in Germany for tools by engravers and watchmakers ; he divided it into four pieces, and treated them in the ſame way as he had done the bliſtered ſteel. The first piece, which was cooled in the air, it was very difficult to break : the fracture appeared in the midſt of the grain very fine, but white and ſhining. The ſecond, which was tem­pered in water, was broken into three fragments at the