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ON

PLANE METALLIC SURFACES,

OR

TRUE PLANES.

The method hitherto adopted[1] in getting up plane surfaces has been (after filing to the straight edge) to grind them together, with emery. In some cases it has been customary to try them previously on a surface plate, and to go over them with the scraping instrument; but they have always been ground afterwards. The surface plate itself has been invariably treated in the same manner.[2] The process of grinding is, in fact, regarded as indispensable wherever truth is required, yet that of scraping is calculated to produce a higher degree of truth than has ever been attained by grinding. In reference to both processes a great degree of misconception prevails, the effect of which is materially to retard the progress of improvement, and which it is of great importance to remove. While grinding is universally regarded as indispensable to a finished surface, it is, in fact, positively detrimental. On the other hand, the operation of scraping, hitherto so much neglected, constitutes the only certain means we possess for the attainment of accuracy. A few remarks will clearly illustrate the truth of this statement.

[1] [2]

It is required, in a plane surface for mechanical purposes, that all the bearing points should be in the same plane, — that they should be at equal distances from one another, — and that they should be sufficiently numerous for the particular application intended. Where surfaces remain fixed together, the bearing points may, without disadvantages be fewer in number, and, consequently, wider apart; but, in the case of sliding surfaces, the points should be numerous and close together.

A little consideration will make it evident that these conditions cannot be obtained by the process of grinding. And, first, with regard to general outline, how is the original error to be got rid of? Let it be supposed that one of the surfaces is concave, and the other a true plane. The tendency of grinding, no doubt, will be to reduce the error of the former, but the opposite error will, at the same time, be created in the true surface. The only case in which an original error could be extirpated, would be, when it was met by a corresponding error, of exactly the same amount, in the opposed surface and the one destroyed the other. But it is evident, that where only two surfaces are concerned, the variety of error in the general

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outline is not sufficient to afford any probability of mutual compensation.

It will further appear, that if the original error be inconsiderable, the surfaces must lose instead of gaining truth. It results from the nature of the process that certain parts are acted upon for a longer time than others. They are consequently more worn, and the surfaces are made hollow. Nor is there any possibility of obviating this source of error, except by sliding one surface entirely on and off the other, at each move, a method which, it need not be shown, would be impracticable.

It may be mentioned, as an additional cause of error, that the grinding powder collects in greater quantity about the edges of the metal than upon the interior parts, producing the well-known effect of the bell-mouthed form. This is particularly objectionable in the case of slides from the access afforded to particles of dirt, and the immediate injury thereby occasioned.

Another circumstance materially affecting the durability of ground slides is, that a portion of the emery employed becomes fixed in the pores of the metal, and causes a rapid and irregular wear of the surfaces. If grinding be not adapted to form a true general outline, neither is it to produce accuracy in the minuter detail. There can be little chance of a multitude of points being brought to bear, and distributed equally, under a process from which all particular management is excluded. To obtain any such result, it is necessary to possess the means of operating independently on each point, as occasion may require, whereas grinding affects all simultaneously. It is subject neither to observation nor control. There is no opportunity of regulating the distribution of the powder, or of modifying its application, with reference to the particular condition of different parts of the surface. The variation in the quantity of the powder and the quality of the metal, will, of necessity, produce inequalities, even supposing they did not previously exist. Hence, if a ground surface be examined, the bearing points will be found lying together in irregular masses, with extensive cavities intervening. An appearance, indeed, of beautiful regularity is produced, and hence, no doubt, the universal prejudice so long established in favour of the process. But this appearance, so far from being any evidence of truth, serves only to conceal error. Under this disguise surfaces pass without examination, which, if unground, would be at once rejected. Another evil of grinding is, that it takes from the mechanic all sense of responsibility, and all spirit of emulation, while it deludes him with the idea that tbe surface will be ultimately ground true. The natural consequence is, that he slurs it over, trusting to the eflfect of grinding, and well knowing that it will efface all evidence either of care or neglect on his part.

It thus appears that the practice of grinding has altogether impeded the progress of improvement. A true surface, instead of being in common use, is almost unknown.[3] Few mechanics have any distinct knowledge of the method to be pursued for obtaining it, nor do practical men sufficiently advert, either to the immense importance, or to the comparative facility of the acquisition.

Due latitude must be allowed to the expression "true surface." Absolute truth is confessedly unattainable. Moreover, it would be possible to aim at a degree of perfection beyond the necessity of the particular case, the difficulty of attaining which would more than counter-balance its advantage. But it is certain that the progress hitherto made falls far short of this practical limit, and that considerations of economy alone would carry improvement many degrees higher. The want of it in various departments of the arts and manufactures is already sensible. The valves of steam engines, for example; — the tables of priating presses, — stereotype plates, — surface plates, — slides of all kinds, require a degree of truth much superior to that they generally possess. In these, and a multitude of other instances, the want of truth is attended with serious evils. In the case of the slide valves of steam engines, there is occasioned a great loss of steam power, and also an immense increase of wear and tear.[4] In stereotype printing, inaccuracy of the plates renders packing necessary to obtain a uniform impression. A vast amount of time and labour is thus sacrificed, and the end is, after all, but imperfectly attained.

The extensive class of machinery, denominated engine tools affords an important application of the subject. Here every consideration combines to afford accuracy. It is implied in the yery name of the planing engine. The express purpose of that machine is to produce true surfaces, and it is itself constructed of slides, according to the truth of which will be that of the work performed. When it is considered that the lathe and the planing engine are used in the making of all other machines, and are continually re-producing surfaces similar to their own, it will manifestly appear of the first importance, that they should themselves be perfect models.[5] There is, perhaps, no description of machinery which would not afford an illustration of the importance belonging to truth of surface, and at the same time, of the present necessity for material improvement; nor is there any subject connected with machines, the bearings of which, on public interests, whether manufacturing or scientific, are more varied or more extensive.

The improvement so much to be desired, will speedily follow upon the discontinuance of grinding. Recourse must then be had to the natural process. The surface plate and the scraping instrument will come into constant use, affording the certain and speedy means of attaining any degree of truth which may be required. A higher standard of excellence will be gradually established, the influence of which will be felt throughout all mechanical operations, while, to the mechanic himself, a new field will be open, in which he will find ample scope for the exercise of skill, both manual and mental.[6] The subject will be best illustrated by a description of the process.

There are two cases for consideration, in reference to the preparation of surfaces,— the one, where a true surface plate is already provided, as a model for the work in hand, and the other, where an original surface is to be prepared.

The former case is that which will generally occur in practice. The method to be pursued is simple, and requires care rather than skill. Colouring matter, such as red ochre and oil, is spread over the surface plate, as equally as possible; the work in hand, having been previously filed up to the straight edge, is then applied thereto, and moved slightly to fix the colour, which, adhering to the parts in contact, afterwards shows the prominences to be removed by the scraping instrument, and the operation is frequently repeated. As the work advances, a smaller quantity of colouring matter is used, till at last, a few particles spread out by the finger suffice for the purpose, forming a thin film over the brightness of the plate. A true surface is thus rendered a test of the greatest nicety, whereby the smallest error may be detected. At this stage of the process, the two surfaces must be well rubbed together, that a full impression may be made by the colour. The higher points on the rising surface become clouded over, while the other parts are left more or less in shade. The dappled appearance thus produced, shows to the eye of the mechanic, the precise condition of the new surface in every part, and enables him to proceed with confidence in bringing it to correspondence with the original. Before this can be accomplished, however, the scraping instrument must be employed, the file not having the precision or nicety requisite to finish the operation. Experience will be a sufficient guide when to exchange the one for the other. It will be found, that when the parts to be operated upon have become to any considerable extent subdivided, scraping is much the more expeditious method. The instruments should be made of the best steel, and carefully sharpened to a fine edge on a Turkey-stone, the use of which must be frequently repeated. They may be conveniently made of worn-out files. It will be matter of discretion, as before remarked, how far to proceed in working up the minute detail, but it is essential that the bearing points, whether more or less numerous, should be *equally distributed*, and a uniform character preserved throughout. This rule should be carefully observed during the progress of the work, as well as at its conclusion.

In order to secure the equal advance of all the parts together, particular attention must be paid to the colouring matter, both with reference to the quantity employed, and its equal distribution. If too small a

quantity be used in the first instance, it will afford no evidence of the general condition of the surface. It will merely indicate the particular points which happen to be most prominent, and to reduce these in detail would be only a waste of time, so long as they are considerably above the general level.

When the surface is finished, if it be rubbed on the plate without colour, the bearing points will become bright, and the observer will be able to judge of the degree of accuracy to which it has been brought. If it be as nearly true as it can be made by the hand, bright points will be seen diffused throughout its whole extent, interspersed with others less luminous, indicating thereby the degree of force with which they respectively bear.

In getting up a surface of considerable extent, it is necessary to take into account the strain which the metal suflfers from its own weight, and the length of time required to produce the full effect on the external form. It will be found, for example, that after a piece of metal has remained for some days in one position undisturbed, it assumes a form different from that which it had while undergoing preparation. Hence, it is desirable to provide for the work while in hand, similar support to what it will have when applied to its intended use.

Another disturbing cause is the unequal contraction of the metal in cooling, when originally cast. The mass assumes the curved form, and is pervaded by elastic forces counteracting each other. These continue in permanent activity, and any portion of metal, taken from any part, tends to disturb the balance previously established.

It remains to consider the second case proposed, viz., how to prepare an original surface. A brief description of the proper method will still further illustrate the case already considered, and will also show how surface plates are to be corrected. Take three plates of east iron, of equal size and proportionate strength. The metal should be of a hard quality. The plates should be well ribbed on the back to prevent them from springing, and each of them should have three projecting points on which to rest, placed triangularly in the most favourable positions for bearing. The object of this provision is to insure constant support at the same points. The plate would otherwise be subject to perpetual variation of form, owing to the irregular strain, occasioned by change of bearing.[7] A provision of this kind is equally necessary while the plate is undergoing the operation of correction, and when it is afterwards used as a model.

In fixing the plates on the table of the planing machine, care should be taken to let them bear on the points before mentioned, and to chuck them with as little violence as possible to the natural form, otherwise they will spring on being released, and the labour of filing will be increased in proportion. It is proper also to relax the chucks before taking the last cut. With these precautions, if the machine itself be accurate, and the tool in proper condition, the operation of planing will greatly facilitate the subsequent process.[8]

The plates are next to be tried by the straight edge, by a skilful use of which a very small degree of inaccuracy may be detected. Let one of the three plates be now selected as the model, and the others be surfaced to it with the aid of colouring matter. For distinctness they may be called Nos. 1, 2, and 3. When Nos. 2 and 3 have been brought up to No. 1, compare them together. It is evident that if No. 1 be in any degree out of truth, Nos. 2 and 3 will be alike, and the nature of their error will become sensible on comparing them together by the intervention of colour. To bring them to a true plane, equal quantities must be taken in both from corresponding places. When this has been done with all the skill the mechanic may possess, and Nos. 2 and 3 are found to agree, the next step is to get up No. 1 to both, applying it to them in immediate succession, so as to compare the impressions. The art here lies in getting No. 1 between the two, which is the probable direction of the true plane. It is to be presumed that No. 1 is now nearer truth than either of the others, and it is therefore to be again taken as the model, and

the operation repeated.

It will be observed that the process now described includes three parts, and consists in getting up the surfaces to one another in the following order: —

1st. Nos. 2 and 3 to No. 1.
2nd. Nos. 2 and 3 to each other.
3rd. No. 1 to Nos. 2 and 3.

These parts compose an entire series, by repeating which a gradual approach is made to absolute truth, till further progress is prevented by inherent imperfection.

In the earlier stages, the operation may be greatly expedited by judicious management. It has been already remarked, but it cannot be too often repeated, that the general outline of the surface should be solely regarded in the first instance, and the filling up deferred till after general truth has been secured. By this method, the first course of the series will be short, and the progress made will be both more speedy and more sure, the minuter detail being gradually entered upon, without the risk, otherwise, incurred, of losing previous labour. As, however, the surfaces approach perfection, the utmost caution and vigilance will be necessary to prevent them from degenerating. This will inevitably happen, unless the comparison be constantly made between them all.

In the use of the surface plate, care should be taken to prevent unnecessary injury, whether superficial or from straining. It should also be occasionally submitted to careful correction, and should invariably be supported on three points. In no other way can a high standard be maintained.

It will be found convenient to set apart one plate for the purpose of comparing others, allowing it to remain entirely undisturbed. It would otherwise be necessary, at every revision, to repeat the process for obtaining an original surface, and a considerable loss of time would thus be occasioned.

A mistaken idea prevails that scraping is a dilatory process,[9] and this prejudice may tend to discourage its introduction. It will be found, however, to involve the sacrifice of less time than is now wasted on grinding. Were the fact otherwise, it would be no argument against the preference due to the former. But it is worthy of observation that, in this instance, as in many others, improvement is combined with economy. There is not only an incalculable saving effected by the improved surface, in its various applications, but there is also a positive gain of time in the preparatory process.

1. ↑ That is, prior to the year 1840.
2. ↑ Surface plates consist (as is well known to those familiar with our workshops) of iron plates, strengthened by ribs on their backs, and having their faces as smooth and as true as possible. They are used for the purpose of testing and correcting any surfaces which are required to be made true. A straight edge is also used for testing the truth of surfaces; it is generally so called when its surface is very narrow as compared with its length, being usually the side face of a long flat bar. Surface plates are made of various sizes. A simple and interesting experiment may be tried with a pair of true surface plates. If one of them be allowed to slide on the other so as to exclude the air, the two plates are caused to adhere together with considerable force, by the pressure of the atmosphere. The surfaces should be well rubbed previously, with a dry cloth, till they are perfectly free from moisture, that the experiment may afford a fair test of accuracy. If any moisture be present it will act like glue, and cause adhesion to take place, supposing the surfaces to be much inferior. But if they be perfectly dry, adhesion proves a high degree of truth, rarely attained. The

experiment may be varied, by letting one surface descend slowly on the other, and thus allowing a stratum of air to form between them. Before they come into contact, the upper plate will become buoyant, and will float on the air without support from the hand. This remarkable effect would seem to depend on the close approximation of the two surfaces at all points, without contact in any — a condition which could not be obtained without extreme accuracy in both. The escape of the remaining portion of air is retarded by friction against the surfaces, the force of which nearly balances the pressure of the upper plate. If one end of the upper plate be slightly raised, and allowed to fall suddenly, the intervening air will act like a ushion, causing a muffled sound to be emitted, quite different from that usually pro- duced by the concussion of metallic bodies.

3. ↑ This, it must be borne in mind, had reference to the state of things existing in 1840.
4. ↑ Mr. Dewrance, superintendent of the locomotive department of the Liverpool and Manchester Railway, in a letter to Mr. Whitworth, dated the 23rd of December, 1840, says,— "In answer to yours of the 20th inst. respecting the difference of the slide valves got up with emery, and those that are scraped or got up according to your plan, the difference is as follows: — I have this day taken out a pair of valves got up with emery that have been in constant wear five months, and I find them grooved in the usual way. The deepest grooves are one-eighth of an inch deep, and the whole surface, which is eight inches broad, is one-sixteenth hollow, or out of truth. Those that were scraped are perfectly true, and likely to work five months longer."
5. ↑ It is plain that, in machines intended to be used in reproducing other machines, errors in surface are of the utmost consequence, for the original defects are propagated in an aggravated form.
6. ↑ It is satisfactory to be able to state that the results here anticipated have been long ago realized
7. ↑ The importance of always providing a proper support for standard surfaces is still very often overlooked. The tripod system is, as I have before stated, absolutely essential.
8. ↑ The plates, after having been planed, should be allowed to rest for two or three weeks on their three bearing points. This will afford them time to settle in the form which they will naturally assume.
9. ↑ When grinding was first discontinued in the establishment of Messrs. Whitworth and Co., no mechanic could be induced to take the work on the same terms as before, owing to the supposed extra labour of scraping. But experience has entirely removed this prejudice, and the work is now done with greater despatch.

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