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THE ALIGNMENT OF MACHINERY.

By Mr. WILLIAM SINCLAIR.

No subject was fraught with greater interest to Engineers than the alignment of the various parts that go to make up a machine, engine, or combination of machinery. And probably there was no subject upon which so many different ideas were held, or which called for greater originality and accuracy; and, finally, it was well to consider the far-reaching effect of this important and initial part of the erection of plant. Two machines that were similar in every particular would probably show a marked difference in running; and if careful search were made it was more than probable that such a result could be traced back to the defective alignment in the assembling and erection of either one or both plants.

The subject was far reaching and had many ramifications, so that he could but touch the fringe of it, and doubtless many points would occur to members as he proceeded. Instances might be remembered of work under different conditions to those with which he would deal, and he hoped that his short paper would lead to a discussion upon a subject of which they all knew something, and he felt sure that they had many specialists among them whose everyday work lent itself to interest-

ing modifications of standard practice in alignment, and he had to confess to a certain amount of diffidence in handling a subject so open to criticism.

The lines used in work of this class were piano wires of about 18 I.W.G., tightly stretched from substantial posts near each end of the machine, and a few experiments would soon show to what point the wires could be safely and conveniently tightened. It should be noted that the posts must be altogether independent of the machine and the wires should touch it nowhere.

A good illustration of the positions in which the wires should be placed was afforded by an examination of the drawings of the machinery, as in nearly every case the wires were simply a reproduction of the centre lines, but in a tangible form; and just as the draughtsman built up the machine on paper, working to his centre lines, so should the engineer erecting the machine build up the actual cylinders, cranks and guides, etc.

In work of this class a knowledge of the art of calipering and gauging was of first importance, and it was useless to apply thought and work unless supported by accurate appliances such as spirit levels and calipers. Such conditions, members would think, went without saying, but they came across numbers of men who would do the work with a schnapper line, a carpenter's level and a two-foot rule, and it was an astonishing fact that many a machine was running to-day which had been aligned in such a way and was doing its work well; but he thought the risk was not worth taking, and it could be easily realised that no matter how well the machine might run, accurate work would probably have made it do so even better.

As a general rule, for all measurements gauges should be used of, say, ⅜in. round iron, and a separate gauge made for each point in the alignment system, because, as the work proceeded, each part might require moving slightly one way or another, and to continually shift calipers to suit such a condition was apt to confuse the erector, and furthermore the effect of altering a part of the engine or machine could at once be felt at each point when separate gauges were used and the result of trying one was compared with the other points.

Fig. 1 showed the type of gauge used for cylinder bores and pieces of a hollow circular section, for it must be borne in mind that it was impossible to tighten up a

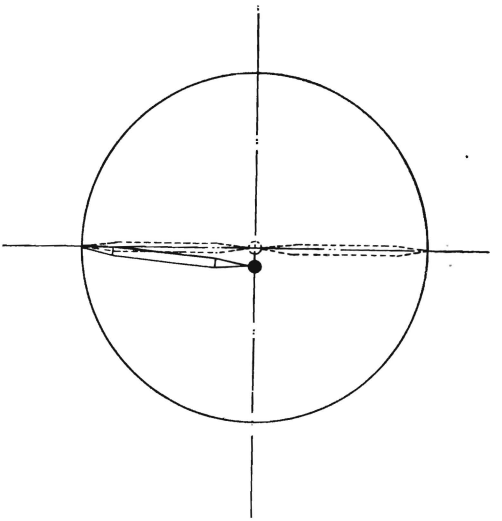


Fig. 1.

horizontal piano wire so that it became an absolutely straight line; so for all horizontal measurements the better way to set about it was to mark with chalk the hori-

zontal centre line of the circle and gauge from these points; then, although the centre was not correct, being more or less above the wire, still the gauging could be accurately done so far as the side alignment was concerned, and the vertical alignment would be dealt with later.

For gauging the line over a crankpin, a gauge of the kind shown in Fig. 2 would be found the easiest to handle. It should be carefully fitted to the fillets, for in a posi-

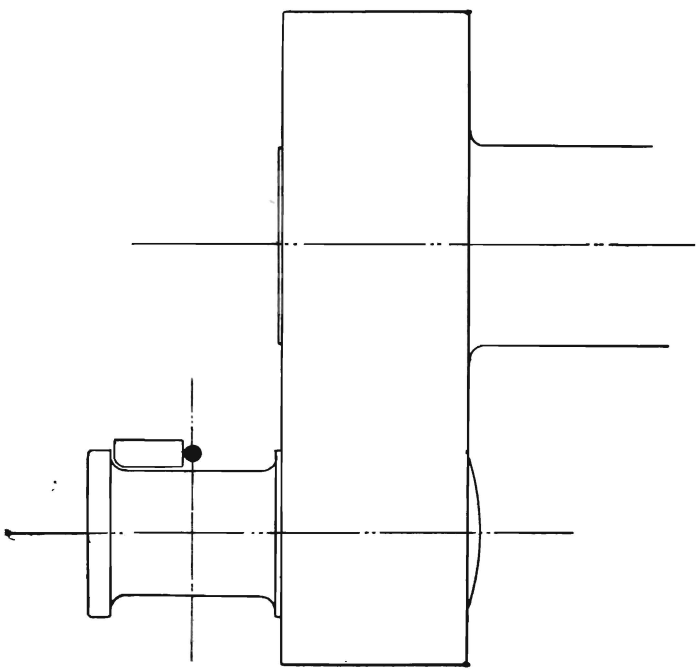


Fig. 2.

tion of this kind calipers were not of much use, although a narrow steel rule would often afford as handy an instrument as the gauge.

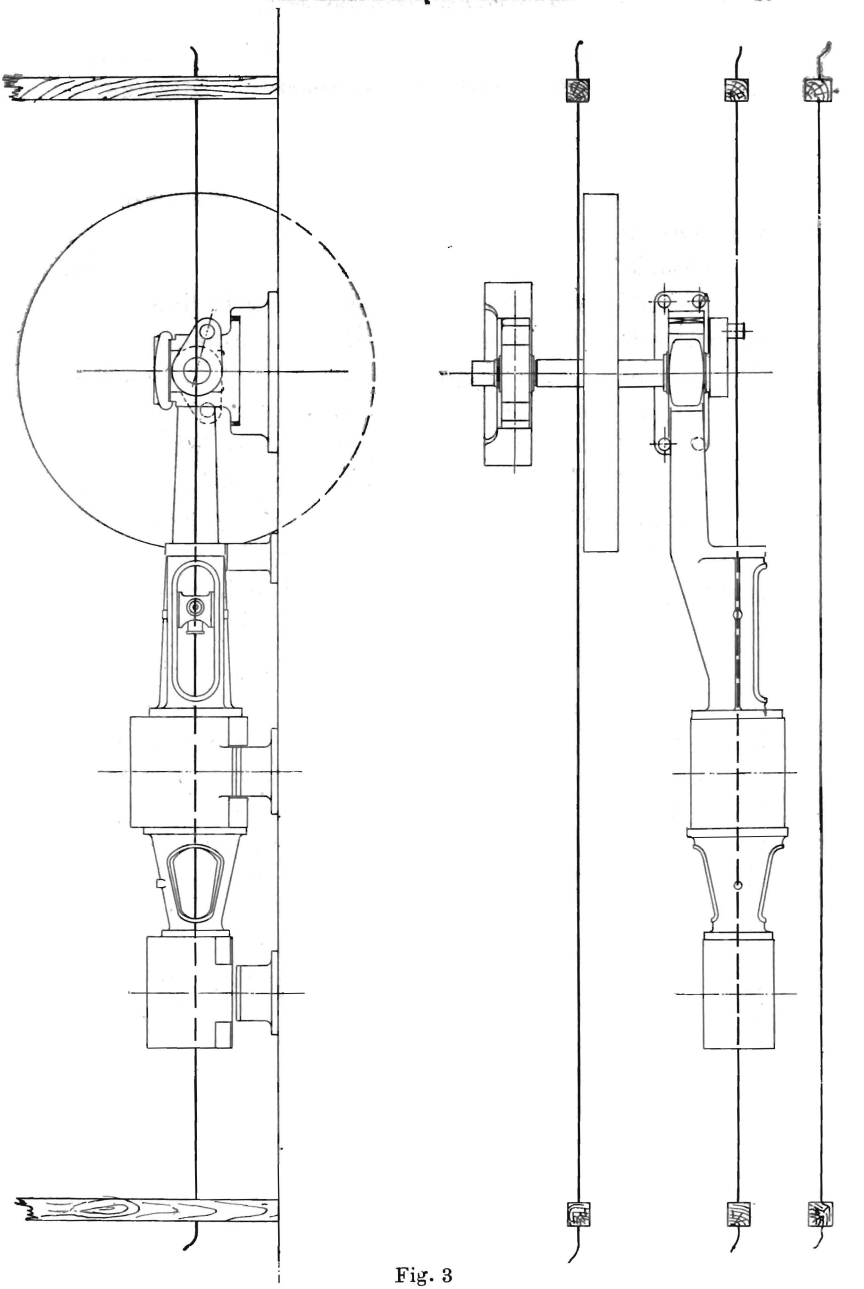


Fig. 3

In Fig. 3 was shown the method of lining off a single crank engine. A multiplicity of parts when aligning such a job was very apt to confuse, therefore the operation should be carried out with as few parts of the engine as possible, the solid unalterable parts only being necessary and convenient. Here it would be seen that there were no cylinder covers in place, for joined cylinder covers with stuffing boxes could be made to come in line almost anywhere by tightening up one side more than another, and no help was got by putting them metal to metal, as the clearance in the studs was a place where error might creep in, and, generally speaking, they were better omitted. The crosshead was in place because, being a trunk guide and open sided, a gauging would only be possible in a vertical line, and the crosshead in place gave horizontal measurements. The crankshaft was in place partially bedded.

The whole scheme of lining off consisted in gradually increasing the accuracy; it was quicker to gradually bring up the alignment by working in every piece than to take one or two parts and adjust them, and then to find that everything had to be gone over again because the other component parts had not been taken into consideration. The author found it a good plan in large work of this class to make a rough sketch of the work and note down at each point what happened as the work proceeded, using for this purpose a set of numbered feelers, as it was practically impossible to recollect each gauging as he moved from point to point, and to talk of "just a feel" and the "thickness of the line", although certainly handy, did not convey much to anyone else except the man with the gauge.

In this engine the points to be gauged would be the inner and outer centres of the crank, the outer and inner ends of the trunk, and each end of the cylinder.

Most engines were so designed that the respective parts, such as trunk, cylinder, distance pieces, etc., all fitted into their proper places, and at first one might say, as was often said, "Put the job up to the shop marks and it won't be far out"; but two arguments could be used against doing this. First, they were perhaps doing the job in the shop starting from bare castings, and this was the first time of alignment; secondly, it was not careful engineering to take such a risk. One of the uses of the lines was to prove work as well as to adjust it, and he had often found that when machinery was transported great distances, and perhaps stored for some time in the sun, long castings had warped, quite apart from the usual warping that was inherent in castings of which one side was machined and the other was rough; also, it must be remembered that when each part went to make up a straight line when they were bolted together, if the joint nearest the trunk should be a little distance out, by the time the H.P. gland was reached the whole engine would be quite an appreciable distance out of truth.

The most important point to be observed in the erection of any engine was to correctly place the crank shaft so that the path of the crank pin was perfectly parallel to the engine centre line, and this condition was checked by turning the crank on to the inner and outer centres and making sure that the wire accurately bisected the centre line of the pin at each of these two points; no other method was to be trusted. But it might possibly occur that when the crank had been shrunk on the shaft it was out of truth, and the engineer erecting it would find that, no matter what he did, no amount of adjustment would bring the shaft into line, so in the event of an occurrence of this kind it was advisable as a further check to run a second line parallel to the fly-wheel rim and to turn the fly-wheel through a revolution to be sure

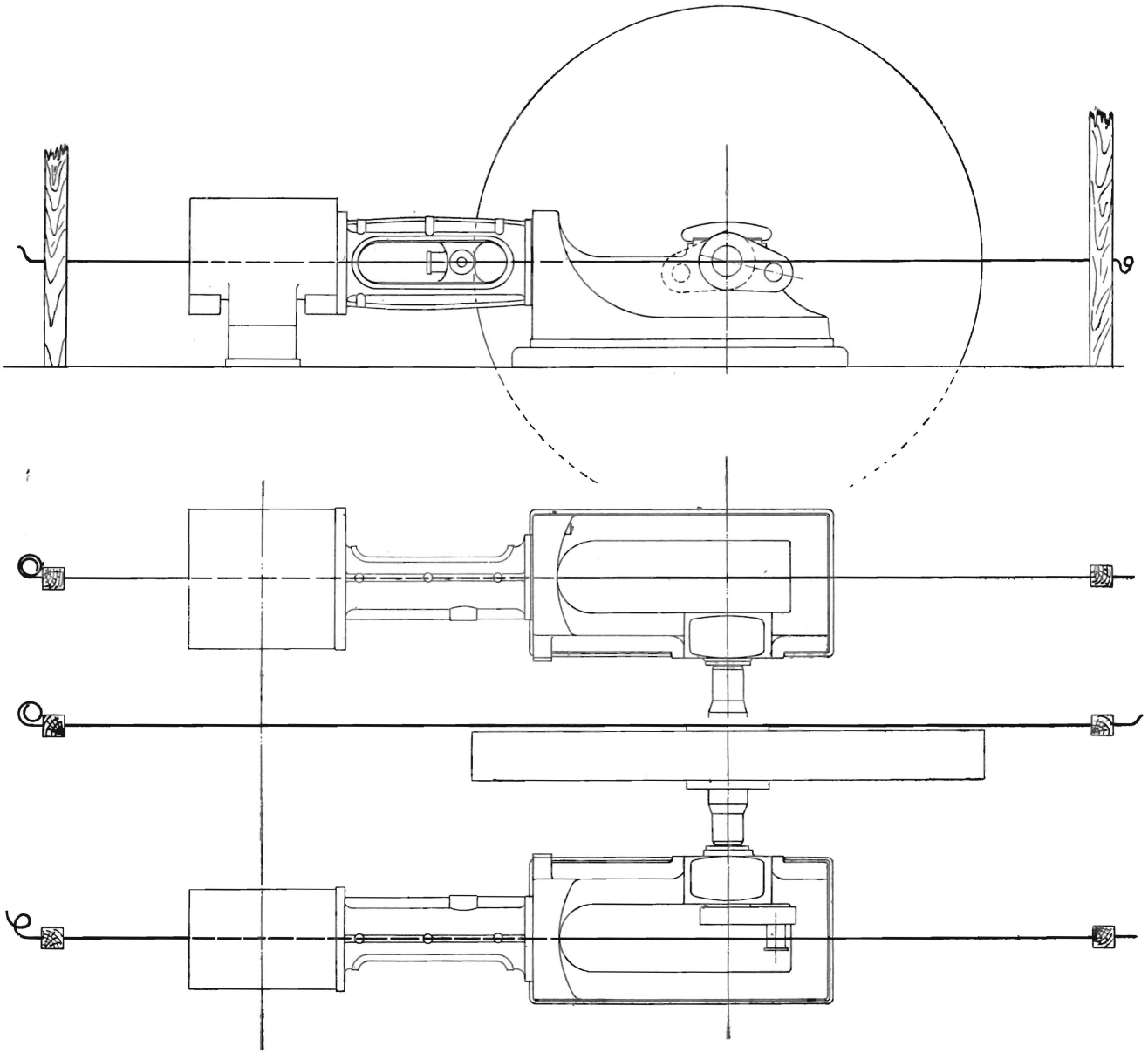
that this second line was true at all points; then, if it proved to be parallel to the engine centre line, they could be quite assured that the fault was not in the shaft but in the web; the pin itself could be checked by means of a square off the face of the crank web.

At the same time that all the parts were being lined off, the levels must be taken in both directions. The bases of the castings should always be placed on flat bar iron so that any lateral movement would not alter the levels. Wedges were not satisfactory except as a preliminary method of raising the various parts.

In addition to the two lines mentioned, the author showed another line running close to the cylinder. This line indicated a method he had used in conjunction with the line near the fly-wheel in order to try the alignment of an existing engine where doubt had existed as to its alignment. It was not so accurate as could be wished, but it served where it was impracticable to draw the running parts and covers and pass a line through in the usual way. The line alongside the engine was first put up and trammelled accurately from the centre of the rear cylinder and from the crank pin path, taking care to level it up. This latter was most conveniently done by means of a dumpy level, but if a dumpy level was not available then a long straight edge laid under the wire and packed up to just touch it was needed, and the level tried on this. The various points, such as centres of glands, crosshead, etc., were then tried with one trammel, and any serious discrepancies would be observed at once.

The line alongside the fly-wheel mentioned before was an additional safeguard in that it checked the right angle line of the crankshaft, but it could only be used

Proceedings of the Engineering Association, Figure 4.



when the flywheel was turned on the edge of the rim, and proved by turning the wheel to two points. This line would, of course, be higher than the other line by half the diameter of the crankshaft, but if it was levelled off with a dumpy level it could be trammelled just the same.

The diagram shown in Fig. 4 was used for lining off a two-crank engine, and most of the remarks appertaining to the single crank engine obtained with this one also. Each engine was treated as a single crank job, and the various points adjusted and then the final point to be tried to make sure that one engine was not in advance of the other, which was just another way of proving the crank shaft alignment. As most engines of this class had long strokes it was sufficiently accurate if the crank-pin centre turned up true to the line at each inner and outer centre on each engine, and if otherwise (always supposing the crankshaft and webs to be true) the adjustment could easily be made by moving one side up or down.

In addition to the above points, it was important to gauge the lines at the terminal points by means of a lath to make sure they had not spread.

A third line was shown here which served the same purpose as in a single crank engine and enabled the crank shaft to be checked or the alignment of an existing engine to be verified.

In each of these examples he had not touched on the question of the limit of error allowable in an engine, as such an allowance could not be stated without knowing every circumstance of any particular job. Large engines of the type shown in the last two figures had many places in them where play was allowed for, and in addition to