THERE are two principal kinds of connecting rods, first those in which the brasses fit in spaces provided in the solid rod, and which are known as solid-ended connecting rods, and second those in which the brasses fit in a strap secured by bolts or keys to the end of the rod. In Fig. 2328 is shown the simplest form of solid-end connecting rod. It consists of a rod enlarged at its end to receive a brass held up to the journal by a set-screw as shown, one-half the bore being provided in the rod and one-half in the brass. The objection to this kind of rod is that as the bore wears the rod gets shorter and no means is provided to restore its length, and that during the pulling stroke of the rod the whole of the strain is concentrated on the end area of the set-screw, and this causes it to imbed in the brass, giving play to the brass

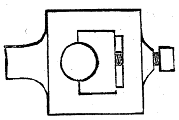

Fig. 2328.

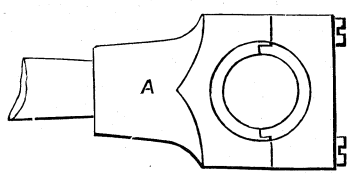

Fig. 2329.

unless frequent adjustment is made. It is, therefore, difficult to readily maintain a very accurate adjustment of fit with a simple set-screw of this kind. This may be to some extent remedied by the construction shown in Fig. 2329 in which the half brass A threads upon the stem of the rod, so that when it wears shorter to the amount of half the pitch of the thread upon the rod end, the brass may be unscrewed half a turn, and the original length will be restored. The cap is held on by two screws, which may have slotted heads as shown, or screws with check-nuts to prevent the screws from slackening back, as all screws are apt to do that receive alternating strains in reverse directions.

Yet another simple form of solid-end connecting rod is shown in Fig. 2330, there being two brasses with a key on one side and a set-screw on the other. In this case, as soon as either brass is moved by the key it can fit the rod at the top and at the bottom only; hence there is but little to hold the brasses sideways in the rod, and furthermore the brasses are damaged from the key and the set-screw acting directly upon them, as will be explained with reference to strap-ended rods. In Fig. 2333 is shown a very

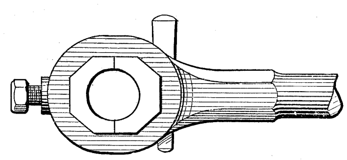

Fig. 2330.

substantial form of solid-ended rod, a sectional view being shown in Fig. 2331. The bottom or back brass A has a flange, as shown in Figs. 2331 and 2332 at A, which secures it to the rod end at the back. The top or key brass B has the keyway partly sunk in it, and the key binds against one side as well as on the bottom of the keyway, and this draws that brass close down to the face of the rod, as shown in Fig. 2331.

In this as in all other connecting rods in which one edge of the key beds against the back of the brass, the taper for the key should be cut in the rod so that the edge which meets the brass will stand square across the opening for the brass; in this way the back of the brass will also stand square across, which is easier to mark off and cut, plane, and fit. If the taper for the key is cut on the brass, marking the latter and fitting it become more difficult, as it must be put in and out of its place to fit and bed the taper for the key edge, whereas, in the other case, it can be squared with a square while planing and fitting. As the bore of connecting-rod brasses wears, and the lost motion incident thereto is taken up (by driving in the key) the location of the brasses in the rod end is altered, making the rod longer or shorter according to the location of the key. But when this wear has been sufficient to let the key pass through the rod, slips of iron termed liners are inserted between the backs or bedding faces of the brasses and the end of the rod or crown of the strap, as

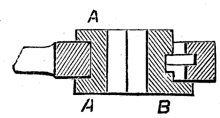

Fig. 2331.

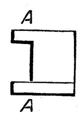

Fig. 2332.

the case may be. In putting in these liners the location of the brasses in the rod end may be adjusted so as to bring the brass back to its original position and restore the rod to its proper length, and in doing so the back brass, as distinguished from the key brass, is the one to be lined first.

In the rod ends shown in Figs. 2333 and 2334 the joint faces (that is the faces where the brasses meet) must be filed away to take up the wear, hence the rods get shorter. In Fig. 2333 the liner may be placed behind either brass, A or B, or behind both, the thickness of that behind A adjusting the length of the rod (which is always measured from centre to centre of the respective brass bores), while the thickness of that placed behind B would simply act to prevent the key from passing so far through the keyway. To prevent as far as possible the wear from altering the length of the rod, the key at one end of the rod is placed outside

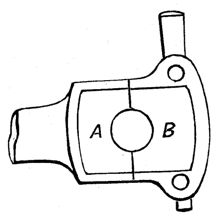

Fig. 2333.

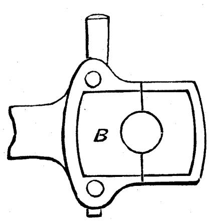

Fig. 2334.

the crank pin or at the outer end of the rod, as in Fig. 2333, while at the other end it is placed between the brasses and the stem of the rod, as in Fig. 2334. In this latter case the thickness of liner placed behind the key brass B (as the brass against which the key bears, or the brass next to the key, is always termed) would adjust the length of the rod, while the thickness of liner placed behind the back brass (as the other brass is termed) would be the one to adjust the distance the key would pass through the keyway.

In this form of rod end, as in many other solid-ended rods, the flange or collar of the crank pin, if solid with the pin, requires to pass through the opening in the rod end which receives the brasses. This may be accomplished by making that opening large or wide enough to pass over the crank-pin collar (which will increase the width of the brasses, and hence that of the rod end); or else the crank-pin collar may have two flat places filed on it, as in the end view shown in Fig. 2335. The objection to

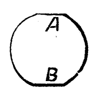

Fig. 2335.

this plan is that the rod can only be taken on and off in one position of the engine; that is, when the two flat places A and B, Fig. 2335, stand parallel with the length of the rod.

It will be noticed in Fig. 2331 that the brass B does not fill the space in the rod. This is because that brass has to pass in over crank-pin collar and push up into the journal after it is in the

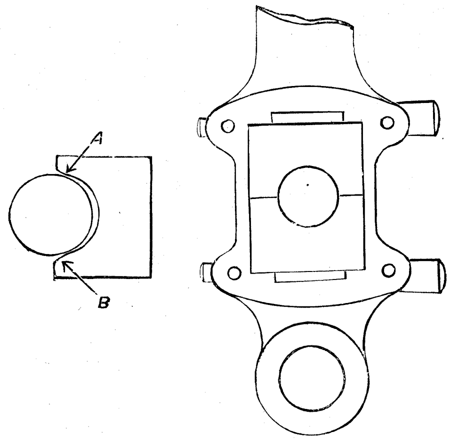

Fig. 2336.

rod. To make this space as small as possible, and to enable giving the crank pin as large a collar as possible, the key brass is sometimes beveled off, as shown in Fig. 2336 at A B. Another form of this rod end is shown in Fig. 2336, in which there are two keys to the brasses, the object being to adjust the keys to maintain the rod of its proper length. In order to facilitate making this adjustment, there should always be upon the face of

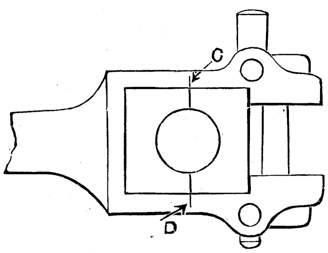

Fig. 2337.

the rod end centrepunch marks, as shown in Fig. 2338 a F and G, or else two deep marks, as shown at C D in Fig. 2337. Then, in lining up the brasses to set the key back, the rod may be restored to its original length by putting behind the back brass a piece of metal of such thickness as will bring the centre of the bore of the back brass B even with the centrepunch or other marks. This being the case, it does not matter about the exact thickness of

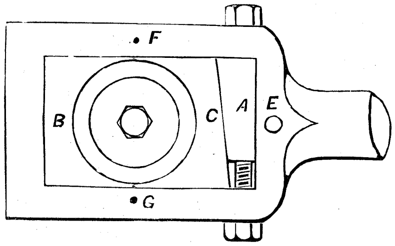

Fig. 2338.

the piece of metal put behind the other brass, since a variation in that will only act to let the key come more or less through the rod end without affecting the length of the rod. In Fig. 2337 is shown a form of rod end sometimes used. The end being open, the brasses pass through it. In this case the whole strain of the pull of the rod falls upon the edge of the gib at top and bottom of the strap, causing the gib to wear out very fast; furthermore, the back brass condenses the metal at the back of the brass opening, acting to pene it and throw the points of the rod end open, which it always does, the jaws of the gib imbedding in the jaws of the rod. This opening of the rod jaws makes the brasses loose in their places; hence this is a weak and undesirable form of rod end, though very convenient to take on and off. In Figs. 2338, 2339, 2340, and 2341 is shown a form of solid-ended rod of more modern construction. In this case a wedge A is used instead of a key, being adjusted by screws passing through the rod at the

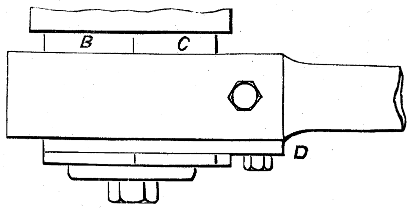

Fig. 2339.

top and bottom, it being obvious that the set-screws may have check-nuts added. B is the back brass, and C the key brass. In this case the flange of the brass goes next to the crank pin, and a plate D is provided to serve as a flange on the front face of the brass. In Fig. 2338 this plate is removed to show the wedge A; but it is shown in the plan view, 2339, and the end view, 2340, and by itself in Fig. 2341. A groove is cut on each side of the two brasses and the plate spans the brasses, passing up the groove being held in position by a screw at E. The opening for

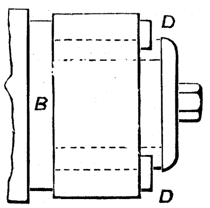

Fig. 2340.

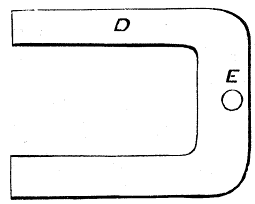

Fig. 2341.

the brass (in the rod end) is here shown wide enough for the rod end to pass over the collar of the crank pin, but in many cases, with this as well as with other forms of solid-ended rods, the crank pin may be made plain—that is, without a flange—and have a washer secured by a screw, so that by removing the washer the rod may be put on with the brasses already in place, and made no thicker (at the joint face) than is necessary for strength. In Fig. 2342 is shown what may be termed a clip-end connecting rod, the screw closing the rod end (to take up the wear) against

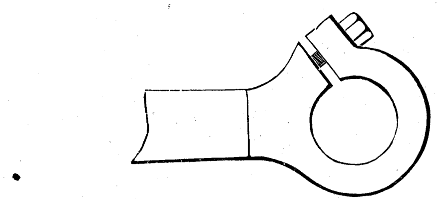

Fig. 2342.

the spring of the metal. It is obvious that in this case the hole may receive a brass bush split as is the rod end and secured from turning by a pin. Fig. 2343 presents another form of solid-end rod, which admits of the use of a brass having a flange on both sides of the strap, and will take on and off by removing the cap B. If the crank-pin collar is solid, the brasses must be placed on the crank pin, and the rod, with the wedge in place, lifted or lowered to the brasses; but if the crank pin has a washer and bolt, the rod may be put together and slipped on its place.

A compromise between the solid and the strap-rod end is shown in Fig. 2344, which represents a design used upon the fast engines of the Pennsylvania Railway. The piece A takes out to enable putting on the rod or taking it off, A being secured in position by the bolt and nuts shown. This forms a solid and durable rod that is much less costly to make than strap-ended rods.

The simplest form of strap-ended connecting rod is that shown in Fig. 2345; S is the strap, secured to the rod end by the key D and

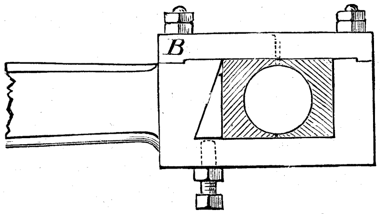

Fig. 2343.

gib C. A is the top, and B the bottom, or crown brass, and E the set-screw for securing the key in its place. [When the rod ends are forged in separate pieces, to be afterwards welded to the stem of the rod after the strap brasses are fitted up (which is done for convenience in handling them while fitting them up), they are termed stub ends.] This form of rod affords great

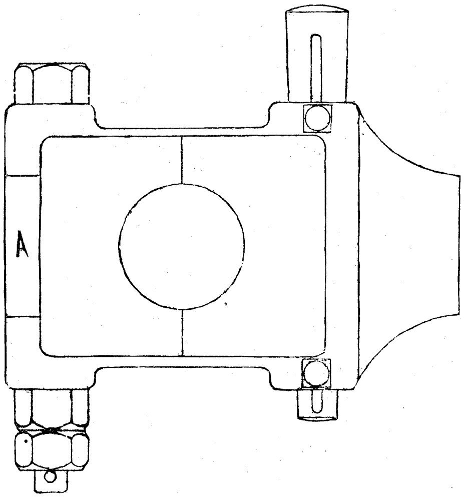

Fig. 2344.

facility for connection with the journals as the strap is easily removed. As the strap, however, is only secured to the rod by the gib and key, and as these have a small amount of area on the sides, it is not unusual to employ two gibs and one key, as in Fig. 2346, which holds the strap more securely, and more effectually prevents its movement sideways upon the rod end. In rods in which gibs

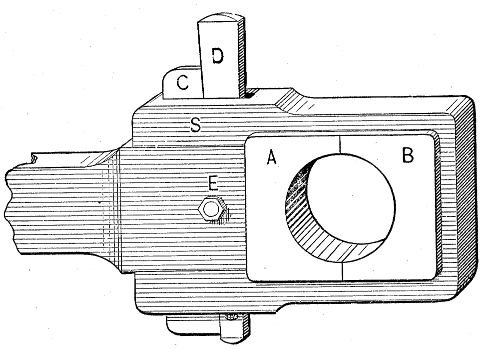

Fig. 2345.

and keys alone are used to hold the strap to the rod, the strap moves along the rod as the key passes farther through the strap, and the fit of the strap to the rod must be easy enough to permit of this motion; hence it cannot be locked to the rod. This, however, may be done by the employment of a bolt as well as a gib and key, as is shown in Fig. 2347. The edge of the gib here abuts against the back of the top brass, or key brass, as it is sometimes termed, which is objectionable, inasmuch as that it is apt to indent the brass, as shown in Fig. 2348 at B. This causes the bore to close at A, and causes the journal to heat, while it makes the brass fit loosely between the jaws of the strap, because it stretches the metal at the back of the brass, which has the same effect as pening it with the hammer.

In Fig. 2349 is shown an end of a connecting rod, such as is

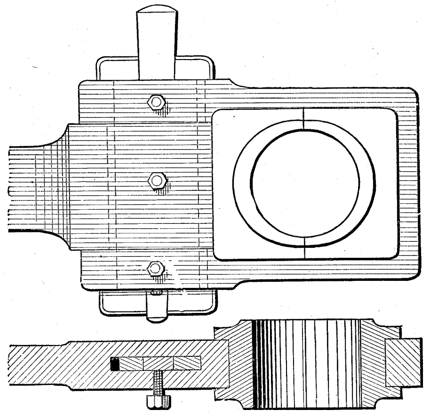

Fig. 2346.

employed on American locomotives, the use of a gib being dispensed with, and the strap being held by two bolts. To prevent the edge of the key from imbedding in the brass, a piece of hardened steel is sometimes placed between the key and the brass, as shown in the figure.

In some designs this method is reversed, the gib being prolonged in a screw-thread, as shown in Fig. 2350, and the key head is carried

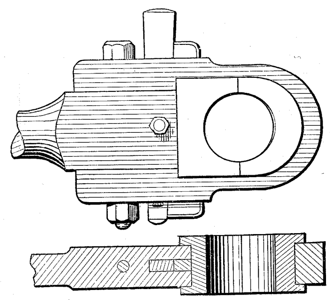

Fig. 2347.

over as shown. Two wing nuts are provided for adjusting the key, which enables its adjustment without the employment of a wrench or hammer.

To prevent the end of the set-screw from raising a burr on the key, which would prevent its easy motion through the keyway, a

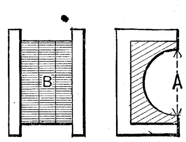

Fig. 2348.

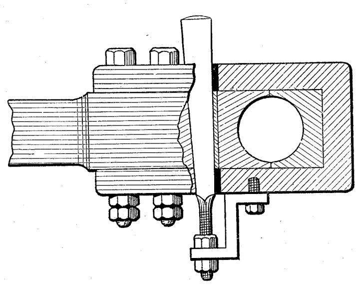

Fig. 2349.

shallow groove is sometimes cut along the key, as in Fig. 2351 at A, the end of the set-screw binding on the bottom of that groove.

In other forms of rod a gib and key are used as well as two bolts. This not only holds the strap very firmly, but it prevents to a certain extent the pening of the back of the brass, explained with reference to Fig. 2348. It is obvious that in the absence of a gib the key moving under friction against the brass stretches the metal more than a gib that presses against the brass, but has no motion endways.

In Fig. 2352 the strap is held by bolts having nuts at each end, instead of a solid head at one end and nuts at the other. The

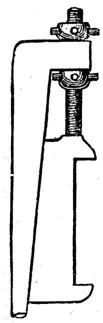

Fig. 2350.

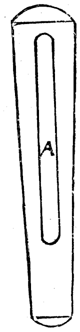

Fig. 2351.

single nuts at the top serve to draw the bolts out when the rod is to be taken apart, thus saving the use of the hammer for that purpose.

In Fig. 2353 is shown a form of rod in which the strap is held by two dies A B, and a bolt which passes through the strap, the dies, and the rod end.

In Fig. 2354 is a form of rod end in which the strap ends are keyed against abutments on the rod by means of the key A. The

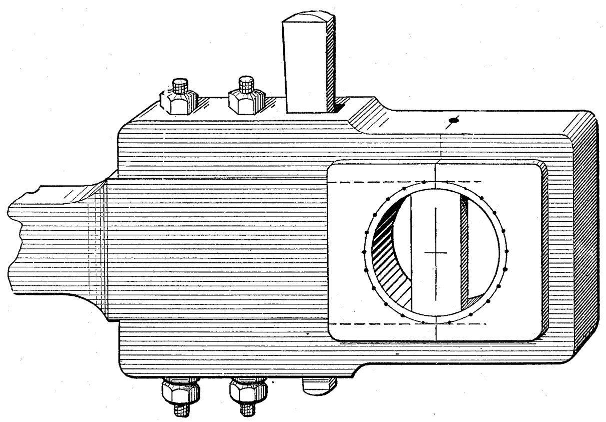

Fig. 2352.

abutments and strap ends being bevelled, keying up the strap with A closes it down upon the rod.

In Fig. 2355 is a form of rod end largely used upon marine engine work; A is the end of the rod, B, B the brasses, and D, D bolts passing through the brasses. Here we have no means of correcting the alteration of length due to the wear, unless a line is marked on

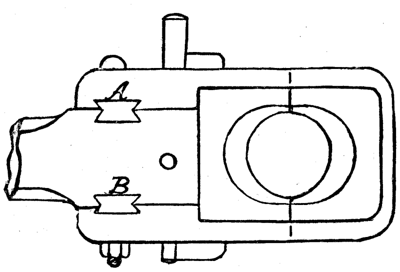

Fig. 2353.

the rod end, as at C, and the distance that line should stand from the centre of the brass bore is marked beside it, as is denoted by the figure in the cut, indicating that the line should stand 9 inches from the cuts of the brass bore.

In general practice the inside jaw faces of connecting rod straps and the faces of the rod are made parallel, which serves very well when the duty and wear is not great; but when the wear and tear is great, as in locomotive work, it is much better to make them taper; indeed, they are in any event better taper, because in that case the brasses can be made a tighter fit. The reason for making them parallel is because they can be more readily planed so than taper; but a parallel strap is more difficult to fit, and cannot be made so good a fit as a taper one, even when new, while it is very much more difficult and expensive to repair.

When the faces of the stub end (or, more properly speaking, of

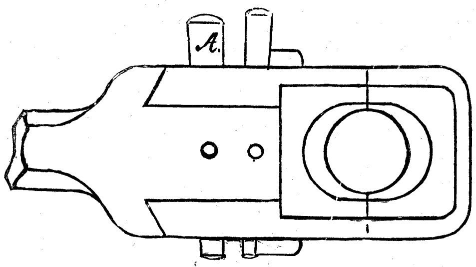

Fig. 2354.

the block) are parallel one to the other, and the inside faces of the strap are also parallel, the strap must be made a very easy fit to the block, in order to be an equal fit from end to end; for if the strap fits as tightly as it should to be a good job, it will, when put on the rod, spring open, fitting across A, Fig. 2356, only; this because the strap springs open from contact at A. The fit, then, can only be such as will not have force enough to spring the strap open, and

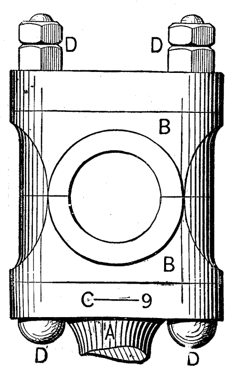

Fig. 2355.

this is very small indeed even in a very strong strap. It is within the mark to state that in a strap measuring 4 inches between jaws, at A in Fig. 2356, it can be forced by hand on the rod sufficiently tight to spring them open $\frac{1}{16}$th of an inch at B,B. When the brasses are fitted into the strap a second difficulty arises, inasmuch as they must be made a very easy fit, or else they will spring the strap open so that it will neither fit at A nor at B, whereas it is desirable that

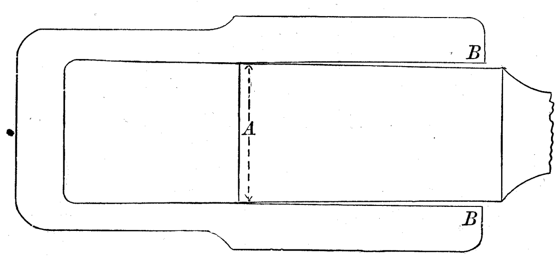

Fig. 2356.

the bottom brass drive home, and the top brass, or one nearest the rod, just push home by hand.

When the rod requires repairing a more serious difficulty arises. Suppose, for example, that the strap requires refitting to the rod, then it must evidently be closed between the jaws, especially if the rod end requires filing up, as it usually does. Now the jaws being parallel cannot be closed without being taken to the blacksmith shop and closed across the crown, as at A in Fig. 2357; for if the jaws are closed (as they might be) by pening the corners B,C the jaws would close as denoted by the dotted lines. The brasses will have to be made larger than the diameter at D, in order to fill the space at A, and will be an easier fit as they pass from D to A, whereas the opposite should be the case. The strap must therefore be closed across A in the blacksmith's fire; this will scale the crown end and render it necessary to file down the whole of the surface on each of the side faces of the strap and rod in order to make them parallel, as they must be to have the flanges of the brasses fit when home in the strap.

The blacksmithing will in most cases render it necessary to file out the keyways, and this again entails the making of a new gib and key. All this extra work may be avoided by making the block and strap a little taper. But before proving this it may be noted that when the rod is made parallel the strap may be made to fit tightly by making the jaws taper, as shown by dotted lines in Fig. 2357;

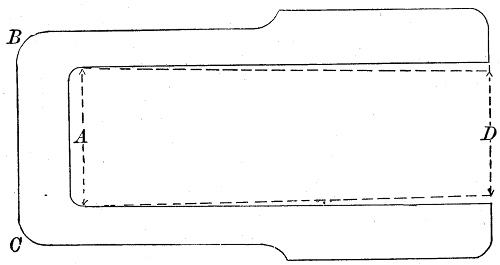

Fig. 2357.

so that when the strap is on the rod, and the jaws spring open by reason of the close fit, the fitting surfaces will be parallel. Such a construction would be faulty however, for the brasses would fit too tight when entering the strap, and get easier as they passed to their places, whereas, as already stated, the exact opposite should be the case.

Let us now observe the advantages of a strap, whose inside faces are made as in Fig. 2358; smaller at A than at B, and also at C than at D, while the thickness from A to B is greater than that from C to D, while the widths C D are less than the corresponding width of the rod.

First, as to fitting the strap to the rod. It may be made so tight to the rod that it will only just pass on when pushed by the hand.

Second, this will render possible a tighter fit than would be possible with a parallel strap and rod.

Third, the width B A being taper, the brasses may be easier

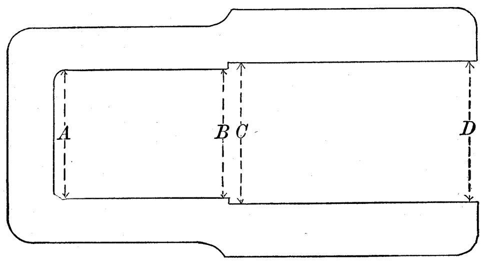

Fig. 2358.

made a good fit, because there will be some metal to fit on after they enter at B.

Fourth, the brasses may be made a tighter fit, the bottom brass being tight enough to spring the strap a trifle, easing but not destroying its fit on the rod.

Fifth, the top brass may be made a handsliding fit to the strap without springing the strap open, which being already under a tension because of the spring due to the bottom brass, will be more rigid and permit of a tighter degree of top brass fit, without springing open and away from the rod.

Sixth, this will leave the bottom brass a tight driving fit, and the top a hand sliding fit, which is desirable, because the top brass has to be taken out to get the rod off while the bottom brass remains in its place.

Seventh, what is of more consequence than all, the strap can be more easily and cheaply refitted to repair it. Thus, in Fig. 2359, suppose the strap to have been closed by pening at D; then whether the end D will be narrowed will depend on the amount the strap was closed, and the amount of taper it had before closing. Let us take, however, the most unfavorable conditions, and suppose that the amount of taper was so small, and the amount of closing by pening so great, that the jaws were made taper and smallest at D. Then the amount to be filed off to bring the width of jaw correct, and a fit to the strap, will be less than if the strap jaws were formed as in Fig. 2357, as will be seen by comparing Fig. 2357 with Fig. 2359, the amount to be filed away being that between the dotted and the full lines in both figures; the amount of closure being the same in the two figures.

But there is another great advantage, inasmuch as in pening, the strap may be pened and tried on the rod, the strap being pened and tried alternately until the required fit is obtained, which is not practicable with upsetting in the blacksmith's shop.

Again, the keyways in the strap will not be set out of true with those in the rod, as they are apt to be when upsetting is resorted to, nor will the strap be scaled; hence the side faces will require but little filing.

Furthermore the step may be located so as to come against the rod end when the wear has let the key down, and this will prevent the strap from passing too far upon the rod, and, therefore, tend to prevent the rod length from being improperly altered from errors in the thickness of the liners placed behind the brasses to take up the wear.

FITTING UP CONNECTING RODS.—The method of fitting up a connecting rod depends entirely upon its size. Very small rods to be made in numbers are usually got out by means of special devices

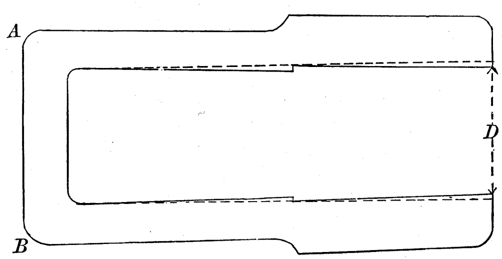

Fig. 2359.

which leave the fitter but little to do; indeed, sometimes the machine work is so accurately and finely fitted and finished as to finish the rod without the aid of the vice hand, save to put it into its place upon the engine or machine. As, however, the dimensions of the rod increase, this method of manipulation is in practice departed from, and the filing, fitting, and adjusting operations increase. In any event, however, the principles to be observed in the manipulation are the same, because the points to be observed in the fitting by hand work must be accomplished by the machine if the rods are to be finished by machine work.

Let Fig. 2360 represent a connecting rod; A representing the centre line in the side, and F the centre line in the edge view, and it is obvious that the axial lines, B and C, of the brass bores must stand at a right angle to line F, and be parallel to each other, because the journals on which they fit will do so. Furthermore, the faces of the brasses, as E, must stand their proper distance from the centre line F, this distance being at each end respectively half the whole width D, and the faces E must be in the same plane whatever their widths may be. The centre lines A and F are imaginary lines not worked to (except it be in marking or lining the rod out for the planing operations); but the method employed to fit up the rod must be such as will make all parts true to those lines if they were tested by them.

The process of fitting up a connecting rod may be tersely stated as follows: 1st, the rod is planed; 2nd, the straps are planed; 3rd, the straps are fitted to the rods; 4th, the straps are drilled and bolted to the rod; 5th, the keyways are cut, and the keys and gibs fitted; 6th, the side faces of the rod ends are again planed with the straps on; 7th, the brasses are fitted and the rods marked off for length and the brasses bored ; and, 8th, the file finishing and polishing done.

In the case of very large rods the two ends are made and fitted up as separate pieces, and are afterwards welded to the body or stem of the rod, and the setting of the ends true one to the other after the welding affords such an excellent insight into the alignment of rods that it may be well to describe it. First, then, the rod being laid on its side, two straight-edges, or rather winding strips, S and S′, Fig. 2361, are placed on the side faces, and the rod will be set in this direction when their ends A, B, C, D, appear parallel when sighted by the eye. If the winding strips are adjusted to stand straight across the rod, and, therefore, parallel one to the other, any twist or wind in the two rod faces will be very plainly discernible by the sighting process. The rod is then stood on edge, as in Fig. 2362, to test the alignment of the side faces. A straight-edge S is pressed firmly against one of the faces, as H in the figure, with the other end

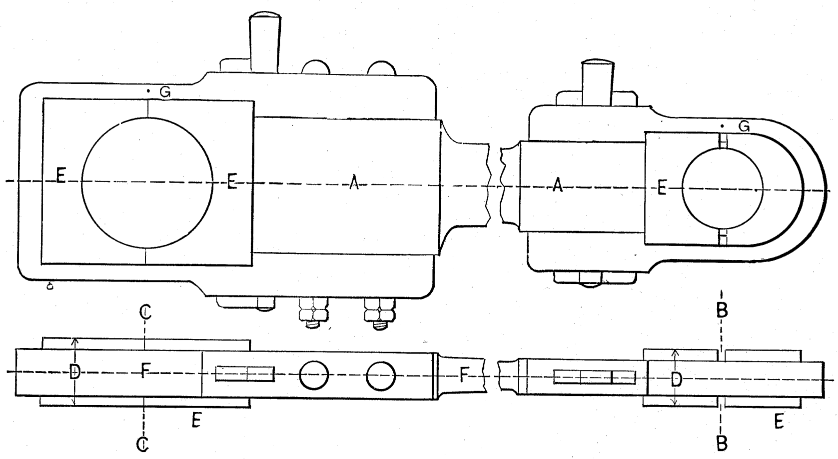

Fig. 2360.

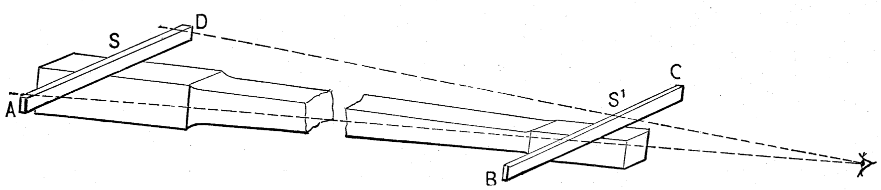

Fig. 2361.

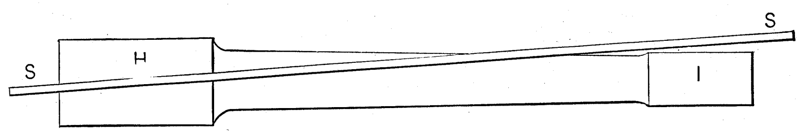

Fig. 2362.

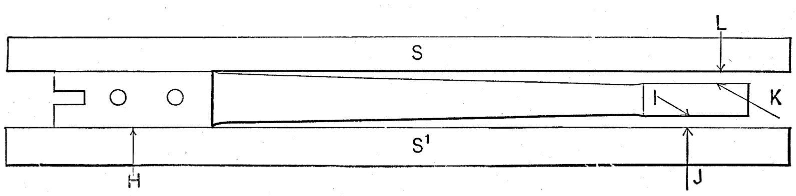

Fig. 2363.

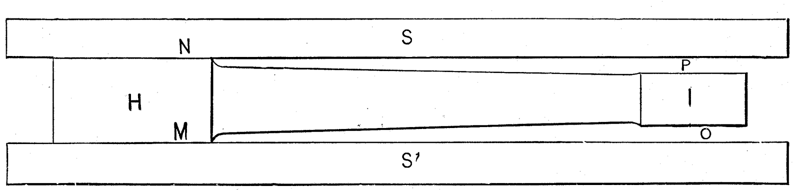

Fig. 2364.

elevated as shown. The elevated end is then lowered, the motion serving to keep the end fairly bedded against face H. The distance, I J, Fig. 2363, is then measured. The straight-edge is then used in the same manner on the other side of the rod as at S in the figure, and the distance K L is measured, the setting in this direction being correct when distances I J and J K are equal. The straight-edge is then applied to the edge faces of end H of the rod, as in Fig. 2364, at M and at N, the distances O, P, are made equal. During these operations a straight-edge is applied along the body of the rod to see where to set it to effect any required adjustment, and if that body is straight the adjustment is made near the end at which the straight-edge is pressed to the rod.

The setting of the small end I is effected in the same manner, but the straight-edge will in this case fall over the face at the larger end, as is shown in Fig. 2365 ; hence, instead of measuring, lines as G and T are marked coincident with the edge of the straight-edge and the distances T U, I G, are made equal. Winding strips are applied to the edge faces as well as to the side faces, and as making one adjustment or alignment may alter another, the whole process must be repeated until the whole of the tests prove the setting to be true.

Now suppose the rod to have been forged solid and all these faces to have been made true in the planing, and the first operation is to fit the straps to the rod ends. The strap should be put in place on the rod and moved laterally, when the centre of its motion where it moves the least will be the place where it binds and therefore requires filing. If its side faces come atwist with the side faces of the rod end, as shown in section in Fig. 2366, either the faces of the rod end or the inside faces of the jaw are out of square as denoted by the dotted lines. In any event the face E, Fig. 2367, of the rod end should be surfaced true and made at a right angle to the side face, and if to be made parallel to M, also at a right angle to K, a square and a surface plate are used to test them. If the diameter J is to be smaller than that at H, then the angle of both face E, and its opposite, should be equal with reference to K. These faces should be finished by draw-filing, with the file marks lengthwise of the rod. To fit the strap, proceed as follows: To find where it requires filing, place it on the rod (having previously put red marking on the rod end), and move it endwise and sideways, observing where the least motion takes place when the strap is moved sideways by pressing its crown end, for this point of least motion is always where it fits the tightest. To test the jaw faces for being square apply a straight-edge S, and a square P, Fig. 2368, pressing S against the strap, and P firmly against S.

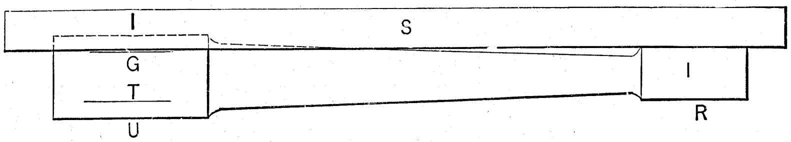

Fig. 2365.

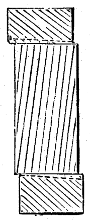

Fig. 2366.

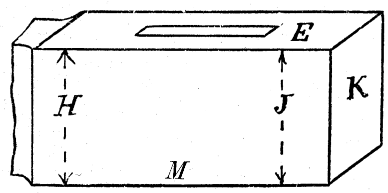

Fig. 2367.

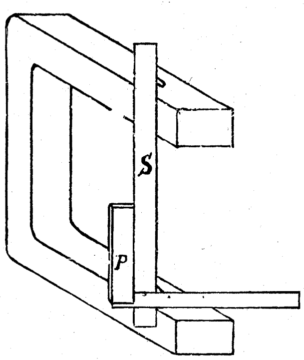

Fig. 2368.

When the strap shows to bed well on the rod and its motion is an ambling one (and not a pivoted one), it fits properly, and if both rod and strap have been filed square, their side faces will come fair or even. The keyways being drilled, may then if necessary be filed out, for which purpose it is necessary to bolt the strap to the rod, a process that requires very skilful treatment, because if the tightening of the bolts moves the strap on the rod, or if the strap be moved on the rod after the clamp is tightened, the keyways will not come fair when the clamp is taken off. In Fig. 2369 the strap is shown held to the rod by plates C and bolts B, the rod being shown in position ready to file out the keyway. It is better, however, to let the side face of the rod stand vertical as the strap will stand steadier that way. The strap should be set fair with the outside faces, which will bring the keyway fair if it is properly located. The bolt nuts should be tightened gradually, first one a little and then another, going over all four once or twice before they are fully tightened, and if the strap is not fair when they are all tight, all must be loosened before the strap is adjusted, or the clamp pressure will cause the strap jaws to spring out of true, and the keyways will not come fair when the clamp is removed.

Should the keyways not come fair when the strap sets fair on the rod the strap may be set to accommodate the keyways, and thus save filing, but this must be done before clamping it to the rod end. Care must, however, be taken to see if cutting the strap out to suit the keyway may not leave too little metal on one side of the keyway when the strap is subsequently planed.

The sides of the keyway should be filed true to a surface plate, using a well-bellied file and as stout a one as possible, so that it may not bend under the pressure, and file away the edges of the keyway.

The keyway should be made parallel to the side face of the strap, so that it may be fair with the centre line F in Fig. 2360. It should be made of equal width throughout, a piece of iron being used as a gauge in place of the key, and this same piece of sheet iron will serve as a gauge to plane the keys to thickness.

The corners of the keyway, if to be made square, should be filed out with the corner of a smooth half-round file, because the corners even of safe-edge files do not come up sharp enough.

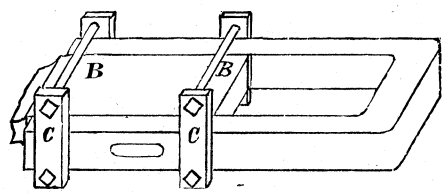

Fig. 2369.

For filing out the end faces of rectangular keyways, a square file with both edges safe must be used, the safe edges being on opposite sides of the file. For roughing out, a taper square, but for finishing, a parallel, or equalizing file is preferable.

The next operation is to fit the keys and gibs. The key should first be fitted and should be filed true to a surface plate, for in no other way can a really good reliable gib be obtained, no matter how well the keys may have been planed or milled. It should be filed a tight fit to the keyway so that it may be used (with a light coat of red marking) to show tight places in the keyway, driving the key in for that purpose from first one and then the other end of the keyway. If, however, it is driven too forcibly, it may seize or cut, and it will be difficult to get it out, besides damaging both it and the keyway. When the keys are reduced so that they will drive lightly into the keyway, they should be tried in the rod and in the strap separately, moving the key laterally or edgeways, so that it may mark any high places in the keyway of either of them.

The finished key and gib should be left tight enough, that they will hold themselves in any position in the keyway of the strap or of the rod when standing vertical.

The head of the gib should be chamfered as in Fig. 2370, so that it may be driven in and out to fit without raising burrs which would prevent it from passing into the keyway, and the key should be similarly chamfered and rounded in its width.

The width of the key and gib should be such as to just fill the keyways, leaving no draw when the key is down in the keyway so that its head is level with the head of the gib, as in Fig. 2371, A equaling the keyway width; and their edges should bed fairly one against the other, and against the edges of the keyway. The strap must then be keyed upon the rod, and the side faces of the rod and strap planed to thickness, placing a bolt and nut in the rod end in place of the brasses, so that the key may lock the strap and bind it in position. The rod end should be planed to thickness for the brasses and of equal thickness on each side of the keyway. The brasses should be planed after the rod end

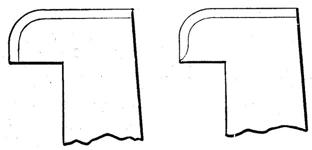

Fig. 2370.

is planed to thickness. The width for the brasses should be measured while the strap is on the rod end, because the width between the jaws of the strap is greater when the strap is in place on the rod end than when it is off, because in order to make the strap jaws a tight fit to the rod end it is made narrower between the jaws than the width of the rod end, so that the jaws spring open when the strap is pushed on the rod end. The sizes for the brasses to be planed to will then be the width of the strap across its edge face, and the width of the strap between the jaws *when it is on the rod;* and for these sizes a wire gauge should be made; or an adjustable gauge may of course be set.

The method to be pursued in planing the brasses is an important consideration. It is most convenient to plane both the brasses together, by which means much time is saved. To obtain this end the brasses are sometimes cast together, as in Fig. 2372, and after planing and before boring are cut in two at the narrow section A. In this case the brasses are cast sufficiently wide from crown to crown as denoted by B, to allow for the length

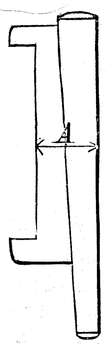

Fig. 2371

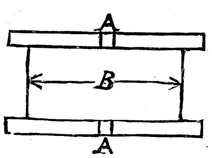

Fig. 2372.

cut away in separating them. In other practice the joint faces of the brasses are faced first and then soldered together for the planing; but very large brasses are planed separately. In either case the joint face of the brass should be made at a right angle to the faces of the brass that fit the strap.

The brasses should be fitted separately to the strap, and hence should, if joined, be separated, being cut in two in a shaper, if of the form shown in Fig. 2372, and split by driving a keen chisel between the corners of the joint faces, if the latter have been soldered. The back or crown brass, and not the key brass, should be fitted first. The corners of the ways, in the brass, for the strap should be eased just clear with the edge of a smooth half-round file, because otherwise they will rub down the sharp edges of the strap, and make the strap jaws appear to be a bad fit when on the rod. The brass should be driven in and out of the strap to fit, using a block of wood to strike on, otherwise the skin of the bore may become pened, and when the brasses are bored they will close in at the sides and become loose in the strap.

As a guide when fitting the bottom brass in the strap, place the strap on the rod as in Fig. 2373, and take the measure of the strap at A A, the strap overlapping the rod to admit the calipers or gauge. Each time the brass is driven in the strap to try the fit, the calipers so set should be tried in the strap (the brass being in the strap), as in the figure, and when the calipers very nearly touch the strap jaws, the strap with the back brass still in should be tried on the rod end, or in the case of a very heavy strap the caliper measurement

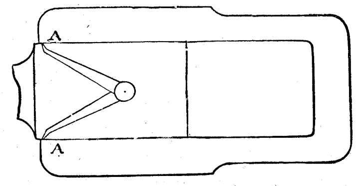

Fig. 2373.

minutely taken may be relied on to show that the brass does not spring the strap jaws too wide open. It is better, however, to leave the brasses a little too tight in the strap as they close slightly in the boring, becoming easier in the strap.

After the brass has been tried in the strap, and before it is filed again, it should be tried with a square, using a straight-edge also if the square back is too short to cross both faces of the brass. The method of testing is shown in Fig. 2374, in which B represents the brass, S the square, and T the straight-edge. The inside face of the flange should also be tried as in Fig. 2375, in which P represents the surface plate, S the square, and B the brass. This will

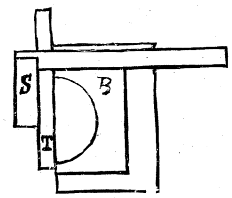

Fig. 2374.

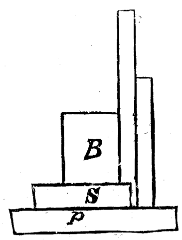

Fig. 2375.

insure that the brass face joint is square as it should be, and is further necessary because the bearing marks on the brass are not to be altogether relied upon.

In Fig. 2376, for example, the brass is shown in section in the strap, and the side A of the brass has a bearing against the jaw B of the strap, and hence would show marks of contact. The succeeding blows in driving the brass, however, may cause the brass to have contact on the side C with the jaw D; hence the bearing marks would show the brass to fit well when such was not the case. This may be detected by striking the brass on its joint face, and then measuring from E and from F to the end of the strap, and then striking the joint face at F and again measuring both distances, when any canting of the brass will readily be detected. It is better, however, to also apply the square, as shown in Figs. 2374 and 2375, because by this means the joint faces E F being parallel to the crown face G of the brass, the brass will be fitted so that when G meets the crown face H of the strap, the two will be parallel to each other and require but little filing to fit or bed together.

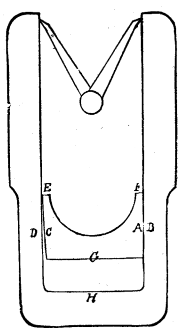

Fig. 2376.

The crown of the brass should be bedded very finely to the strap, or it will spring the strap jaws away from the rod when the key is driven home.

Suppose, for example, that the crown of the brass did not bed well at A in Fig 2377, then keying up the strap would spring its jaws away from the rod end, as shown at B C, the least error in the bedding having this effect notwithstanding the fit of the gib jaws.

The second brass must be made to just fit the strap when the back brass is in its place, and is small enough when the calipers, set as shown in Fig. 2373, and tried as shown in Fig. 2376, just

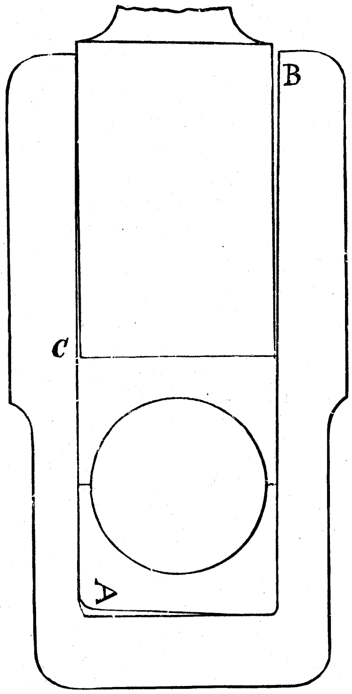

Fig. 2377.

fit the strap. This will insure that both brasses fit the strap when it is in its place on the rod.

When both pairs of brasses have been fitted to their straps, the latter should (if held by bolts) be bolted to their places on the rod, and the centre of the respective spaces for the brasses will be the location for the marks G, G, Fig. 2360. A pair of trammels should, however, be set to the proper length of the rod and these marks tested. If the strap is held by gibs and keys, as in the small end in Fig. 2360, the strap should be put on its place with the gibs in, and drawn up the rod by slowly forcing the key in until the mark G at that end stands in its proper distance from G at the other end, at which time the key should come through its proper distance.

The thickness of the brasses must be measured from these marks G, G to the crowns of the straps and the ends of the rod respectively. If the rod is of its proper length and the straps are in their proper positions, these marks will come in the centre of the space for the brasses. If, however, there is any error, as there is apt sometimes to be in very large rods, the course to be pursued depends upon the kind of rod end. If both straps are bolted to the rod end, the error may be divided equally at each end. If one end has a key and gib or gibs, but no bolt, as at the small end in Fig. 2360, the key brass may be made of such thickness as to butt against the end of the rod and meet the mark G.

For the large end, the thickness of the key brass, or, in other words, the distance D in Fig. 2378, must be taken after the face of the crown brass has been squared up, as described with reference to Figs. 2374 and 2375, the connecting rod strap being placed in such position that the key will be up in its proper place.

When the joint faces of brasses do not meet, but are left open to take up the wear, it is a difficult matter to properly adjust the brass bore to the journal. If the flanges of the brasses do not quite fit the length of the journal, as is very commonly the case, it is customary to tighten the key until the rod end can just be moved by hand so as to force the brass flanges against first one and then the other end of the journal. This is an approximate adjustment; and if the journal heats at all, the key is slacked back a trifle; whereas if it pounds, the key is set up a little. As a matter of fact, then, nothing is actually known of the precise fit of the brass to the journal; and while looseness may be detected by the pounding, the brass may be tight enough to cause undue wear without very sensibly heating the journal, especially if the latter is freely lubricated. If, however, the brasses fit the length of the journal, and do not butt, it is usual to drive the key in till the brasses bind the journal, and to then slack the key back to the necessary amount. What that amount should be cannot be stated, because it varies with the taper of the key and the force with which it is driven home. As a result, then, the operation is left to the judgment, or, in other words, to guess-work, of men, many of whom are not well experienced in the operation; while under any circumstances the actual fit is not positively known. A plan not infrequently adopted is to insert a piece of lead wire of small diameter between the brasses, the key is first driven tightly home, and then slacked back until the lead wire is just freed. It is estimated that the adjustment will then be correct; there is no actual certainty of the fit, however, even in this case.

Another objection is that the oil is apt to flow out of the opening, and the brass having communication with the oil cup is better lubricated than the other brass.

In cases where the brasses are difficult to get out of the strap, because of the location or of the size and weight of the parts, a piece of sheet brass is sometimes placed between the joint faces, and this piece is filed thinner to let the brasses together, the necessary thickness for the piece being ascertained by the lead wire process described. If the strap is held to the rod end by a gib and key only, and the joint faces are left open, there is nothing to lock the strap to the rod end save the jaws of the gib, whereas when the brasses butt, the key binds the brasses to the end face of the rod and the strap to the brasses, which if there is any wear sideways (as in locomotives), prevents the keys from wearing the sides of the keyways and the brass flanges from wearing the straps.

A method of overcoming this defect is shown in Fig. 2379, where the joint faces are left open, and four set-screws S, S, two on each side of the rod, pass through the flange of one brass and abut against the face of the other, serving to adjust the fit of the brasses to the journal, and lock them in their adjusted position, locking at the same time the brasses to the strap and the strap to the rod end.

When the rods are finished so far as the fitting of its various

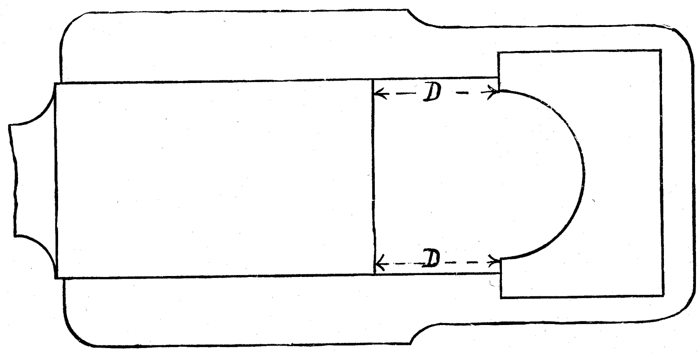

Fig. 2378.

parts are concerned, the brasses should be marked so that the bore, when bored out, will leave an equal thickness of metal between the brass and the strap on each side of the bore, while the rod will be of proper length. To accomplish this, mark on the outside face of

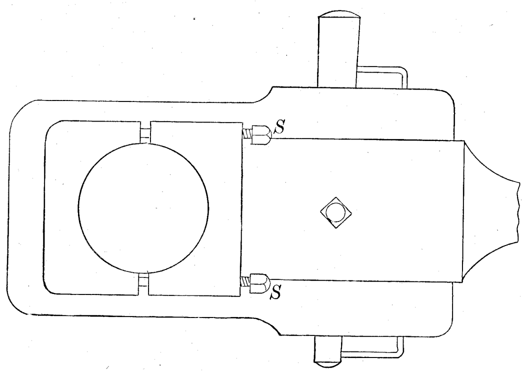

Fig. 2379.

the top brass two lines level with the faces which fit against the inside jaws of the strap, as shown in Fig. 2380, A,B being the lines referred to. We then key up the brasses in their places in the rod and fasten a centre piece in the brasses at each end of the rod. Upon these centre pieces we first mark a line parallel with and central

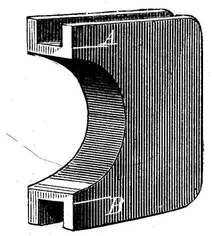

Fig. 2380.

between the lines A,B, and then a line across the joint of the brasses if the joint faces meet, and in the centre of the space between them if they do not meet.

Before applying the trammels to test the rod length, the latter should be stood or placed in the position in which it works when

FITTING UP SOLID-ENDED CONNECTING RODS.—In fitting up solid-ended rods the side faces require to be filed up first and the jaws to receive the brasses next, taking care to file them out either square with the faces, or if slightly taper, as they should be, then each inside face should be an equal degree of taper to the side faces. This is necessary so that if the brasses are bored true to their own faces, the bore of the brasses at one end of the rod shall stand parallel to the bore of those at the other end.

The fitting of the keys and brasses is performed as described for strap-ended rods.

The reason that the jaws or box that receives the brasses is but a trifle taper is that in that case they are easier made a good fit, as they can be tried in their places while being fitted and before being reduced to the finished size, and furthermore because they can be put in and taken out easier.

FITTING UP A FORK-END CONNECTING ROD.—A fork-end connecting rod affords as good an example of vice work as can be

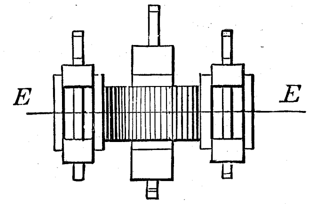

Fig. 2382.

found, because any faulty workmanship, either in the individual truth of the parts, or their relative truth one part to another, will make itself very plainly apparent.

Fig. 2381 represents a side and plan view of an ordinary form of fork-end rod, and the requirements are that the centre line A of the brass bores at the fork end shall be parallel with the centre line B of the bore at the butt end; that the side faces of all the brasses shall be parallel one to the other; that the side faces at the fork end shall be equidistant, or at the required distance, from the side faces at the butt end as denoted by C,D; that the bores of the brasses shall be at the proper distance apart to make the length of the rod come right; that the brasses at the fork end shall be the right distance apart, and that they shall stand parallel to each other, as well as to the bore at the butt end, as denoted by the line E in Fig. 2382.

If the rod were of a size that it could be conveniently handled and planed, if forged solid, the fitting up would be much simplified,

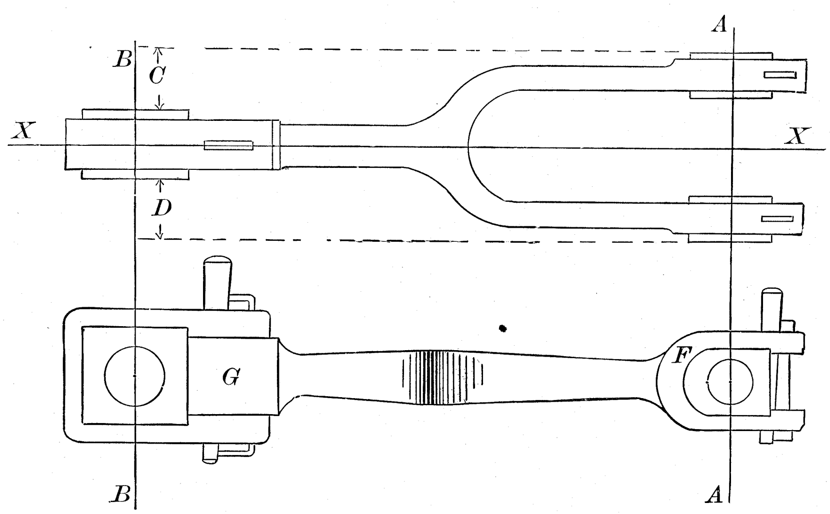

Fig. 2381.

on the engine; for all rods deflect by their weight, the amount of such deflection depending upon the position in which the rod is suspended. The trammels also deflect, it is true, but their deflection is allowed for in setting them, whereas the deflection of the rod will not be accounted for unless it is trammelled when standing or lying in the position in which it works.

because the setting of the rod for the machine operation would, to a great extent, insure truth in the relative alignment of the parts. Thus all the side faces of the rod ends could be planed at one chucking, in which case they would necessarily be parallel, and their proper relative distances apart, if the rod was properly marked out by lines and planed to the lines. The jaws or ways to receive the brasses would be slotted out together, and necessarily true, if the rod was chucked true on the machine table. But even in this case the rod has to be marked out by lines denoting where the

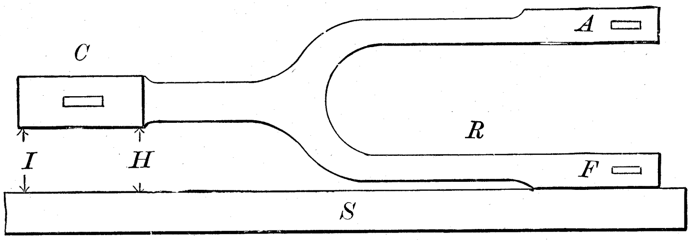

Fig. 2383.

metal is to be cut off to, and the principles involved in the lining are just the same as those involved in the fitting up.

If the rod be large, the ends may be, and usually are, forged and fitted up separately, and subsequently welded to the body of the

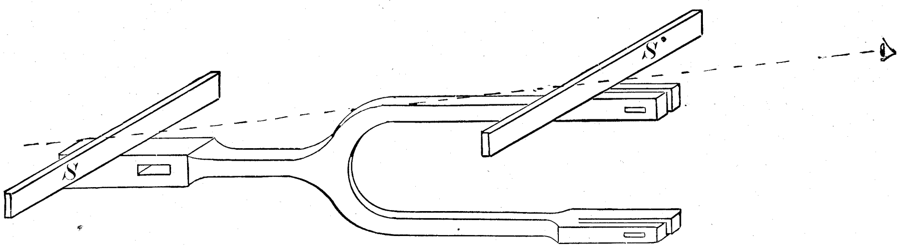

Fig. 2384.

rod, which has been forged separately. In this case, the alignment of the parts is a part of the process in welding the rod, and setting it after welding. All the principles involved in making the rod ends separate, and afterwards welding them, or in marking out a small and complete forged rod, are, however, involved in the process of refitting an old rod in the jaws, and putting in new brasses; hence a description of that process will cover the whole ground. The first thing to do is to file up the side faces, as F,G, Fig. 2381, and, in doing this, all that is necessary is to file F up true, when tested by a straight-edge applied as in Fig. 2383, in which R is the fork and S a straight-edge, whose edge should measure the same distance at H as it does at I from the side face F, while the face C

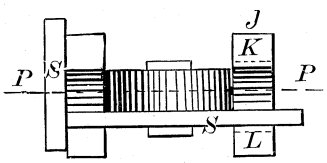

Fig. 2385.

measures the same distance from face A of the other fork end, or from the imaginary centre line X, Fig. 2381. Then turning the rod on its side, a straight-edge should be placed across the face F. and one across the face G, as in Fig. 2384, at S and S' ; and the edges of the two straight-edges should stand parallel, when

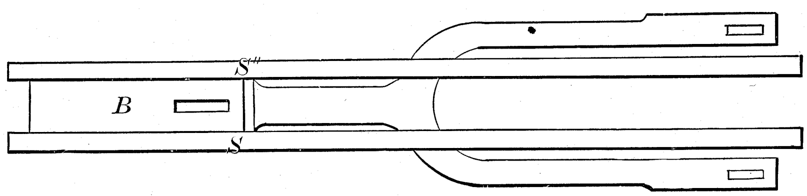

Fig. 2386.

sighted in such a position that the edges are very nearly in line with the eye, as shown in the figure.

The inside faces of the fork jaws may be filed to measurement from the outside ones.

The ways for the brasses should be filed square with the outside faces, as shown in Fig. 2385, in which S is a T-square ; but if one jaw is wider than the other, as sometimes occurs, it will not matter, providing that, with the square applied, resting against the side and the face of the ways on the narrow jaw, the ways of the other jaw are equidistant from the square blade, as would be the case: for example, if the width of the ways of the jaw J extended to the dotted lines at K, L, because the line P would still form the centre line of both jaws, standing at a right angle to the side faces of the fork end, and parallel to the bore of the brasses at the butt end. Before filing up the side faces at the butt end, the strap should be fitted on and keyed up, so that its side faces may be filed

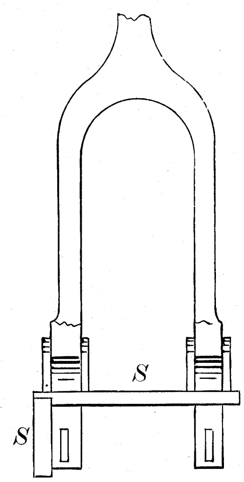

Fig. 2387.

up with those on the rod. To test the truth of the side faces at the butt end, a straight-edge should be applied, as at S and S'', Fig. 2386, being pressed firmly to the side faces at the butt B, the fork faces being measured from the edge of the straight-edge at that end, and also with straight-edges, as in Fig. 2384. The brasses, after being fitted into the ways of the jaws, should have their joint faces squared, as in Fig. 2387, the top of each jaw being shown broken away, so as to fully expose the brasses. S is a square held firmly against the side face of a jaw, the brasses having their joint faces true with the square blade, and true also when tested with a square, applied as in Fig. 2388, in which B is the brass and S the square. The brasses at the other end should be filed true to the side faces of the strap in a similar manner, and, the fitting being completed, it simply remains to mark off the brasses for boring. The joint faces of the brasses should form the centre of their respective bores ; hence, all that is necessary, is to insure that the brasses be of equal thickness, top and bottom, and this may be accomplished as follows : Mark across each face a line even with the ways of the brass, as shown in Fig. 2389, at A, C, and carry these lines around the side face, as shown in the figure at B, D. Place the brasses in the strap, put in a piece of wood whereon the compasses may be rested, as shown in Fig. 2390, which represents one jaw, and mark on this piece of wood a line even with the joint faces of the brasses, and on this line a centre-punch dot equidistant between the lines B D. From this dot, as a centre, strike the circle

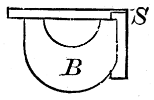

Fig. 2388.

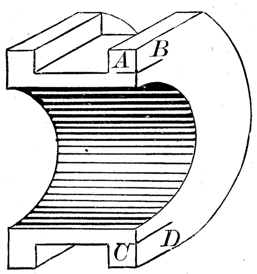

Fig. 2389.

shown, and define it by centre-punch dots, and if the lathe-hand chucks the brasses true to the ways that fit the rod jaws, and to the dotted circle, the bores will stand true in every respect.

REPAIRING CONNECTING RODS.—In repairing connecting rods the following is the work usually required to be done, and in

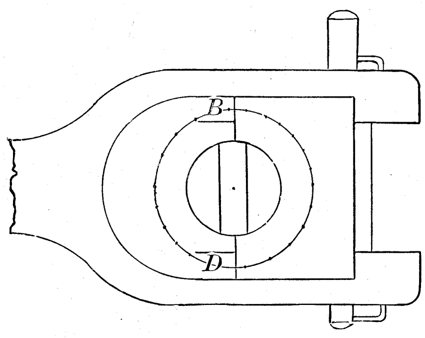

Fig. 2390.

the order named : Refitting straps, refitting gibs, and perhaps new gibs and keys, filing up the side faces of rod ends and straps, lining up brasses to make them fit the strap, lining up the rod to length and fitting the brasses together so as to fit their journals.

If the strap is taper and can be closed by pening, the outside of

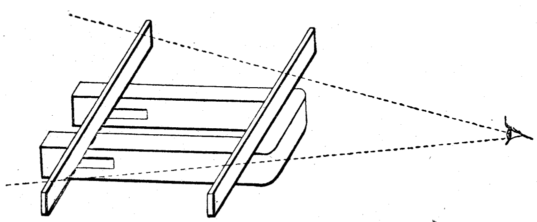

Fig. 2391.

the back should be pened ; but if the strap requires closing in the blacksmith's shop, then it should be tested by winding strips as shown in Fig. 2391, to insure that the faces are true, and thus save filing at the keyways and on the side faces to make them come fair with the rod ends. The rod ends should then be filed up and the straps fitted on.

Next comes putting in the new key and gib, or refitting the old gib. If the jaw of the gib has cut into the strap, as it will do in some cases (especially in marine and locomotive rods), this may

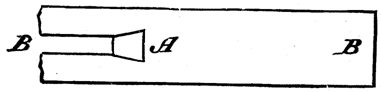

Fig. 2392.

be repaired as follows : Cut out the recess shown in Fig. 2392 at A, making it dovetail-shaped as shown, and with a set chisel set up its sides as shown in Fig. 2393, which is a sectional side elevation through the line of B. Cut out a piece of wrought iron and

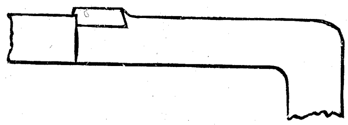

Fig. 2393.

bevel its edges as shown in Fig. 2394, filing it to fit into the recess cut at A, Fig. 2392, and letting the bevelled edge be uppermost. Then take a set chisel and close down again upon the bevelled edge of the piece the metal that was set up, as shown in Fig. 2393, and the piece will be riveted, and it and the gib jaw may be refitted to touch the piece thus let in.

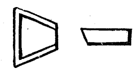

Fig. 2394.

The jaws of the gib are sometimes made slightly taper at A, Fig. 2395.

To refit the brasses to the jaws of the strap, the flanges which do not as a rule wear much are usually tinned with a soldering iron, and given a lining of babbett metal. This must be done all around the flanges (of both pairs of brasses) that come on the same side of the rod, so as to keep the faces of the brasses leading fair.

The fit between the jaws is restored by riveting pieces of sheet brass to that side of the brasses that has worn the most (usually the top which carries the weight of the rod). Fig. 2396 shows this operation carried out, A being the pieces of sheet brass which are sometimes soldered as well as held by rivets. These rivets are screwed into the brass, being composed of softened brass wire riveted after being screwed in.

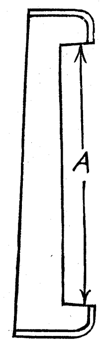

Fig. 2395.

If these pieces, which are called liners, are placed on the top of the brasses at one end, they should also be placed at the top of the brasses at the other end of the rod. They should not be less than about the $\frac{1}{24}$ inch thick, the body of the brass being cut off to admit them if necessary.

In filing the joint faces of the brasses to let them together so as to take up the lost motion due to the wear of the brass bore and of the crank pin, the following considerations are met.

If the brass faces are to come " brass and brass," that is, butt

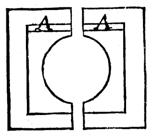

Fig. 2396.

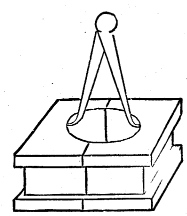

Fig. 2397.

together, when their bore is of the diameter of the journal, file those faces away until the bore appears just perceptibly too large for the journal, when measured with calipers, as in Fig. 2397, the bore measuring parallel all the way through. But, in doing this, it is necessary to be careful to file each brass so that it shall embrace one-half the journal diameter, which will be the case when the two brasses measure correctly as above, and alike, when tested, as in Fig. 2398, in which P is a planed surface, C a pair of inside calipers, and B a brass resting on P. When filing the joint faces, test them with a square as in Fig. 2399, in which *s* is a square and B a brass, and also in Fig. 2400, in which *s* is a

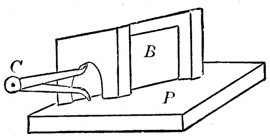

Fig. 2398.

square and B the brass shown in section, thus making the faces quite square.

The necessity of having their faces quite square when the brasses come brass and brass may be shown as follows :—

Suppose the joint to be at an angle as at A, A, Fig. 2401, instead of square across, as denoted by the dotted lines B, B, then the respective brasses will be forced by the key-pressure in the direction of the respective arrows, and there will be a tendency to

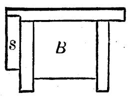

Fig. 2399.

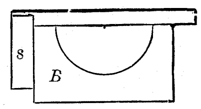

Fig. 2400.

twist the brasses in the strap. Or suppose the joint faces to be out of square as at C, C, instead of square as at D, then there will be a tendency to twist the respective brasses in the direction of E, F, and therefore to cause these to move in the direction of G, H, and as a result the brasses will spring the strap away from the rod, as shown at I, J.

To line up the brasses for length we proceed as follows: One of the liners adjusts the length of the rod and the other simply serves to set the key back to its proper height, so that it shall not

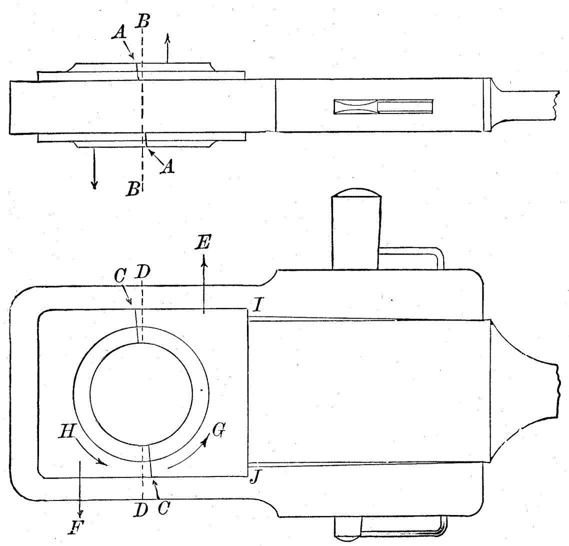

Fig. 2401.

pass too far through the keyway, as the wear of the brasses lets it down. Which of the liners will be the one by which to alter or adjust the length of the rod depends upon the design of the rod itself; but, in the case of all solid-ended rods, or those in which the position of the strap is fixed by means of bolts, it is the liner behind the end brass, as D, in Fig. 2402, as stated in the opening of this discussion, and it is the first one, therefore, to be fitted. The space at E is where the second liner requires to be placed, its thickness being that necessary to lift up the key from its bottom or lowest position, as shown in the cut, to the highest position.

In strap-ended rods in which the strap is not bolted to the rod, but moves farther upon the rod as the key passes farther through the keyway, it is the brass next to the rod end, as B, in Fig. 2403, by which to adjust the length of the rod, and its liner L is, therefore, the one to be fitted first; the space E is, in this case, the one to be fitted with a liner of sufficient thickness to lift the key up. It will now be noted that the thickness of L in both figures requires to be exact, so that the rod may be of correct length, which is necessary, so that there may be the same amount of clearance or space between the piston head and the cylinder cover when the piston is at the respective ends of the stroke.

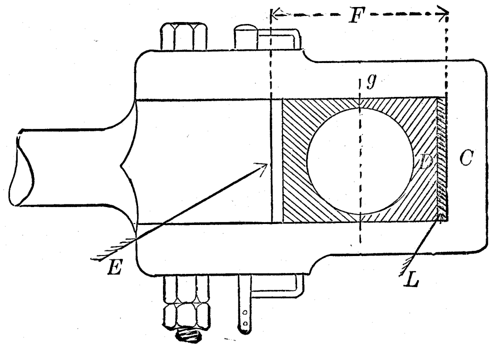

Fig. 2402.

But the liners to fill the respective spaces E need not necessarily be of the exact thickness (although it is better that they should be), because if too thin the only effect will be that the key will pass farther through the keyway than otherwise. In considering in any form of rod which is the liner to be put in first to bring the rod to length, we have the general rule that the brass that moves in the strap or rod end when the key is moved farther through the keyway is the one to be lined last. The method of obtaining the proper thickness of the liners L, Figs. 2402 and 2403, are as follows: If the rods have been correctly made at first, the centre of the brass bores will be midway in the spaces for the brasses (denoted by F in the two figures). If the oil-holes in the strap or rod end (as the case may be) have been drilled in the centre of this space F as they should be, then the line *g* will represent the

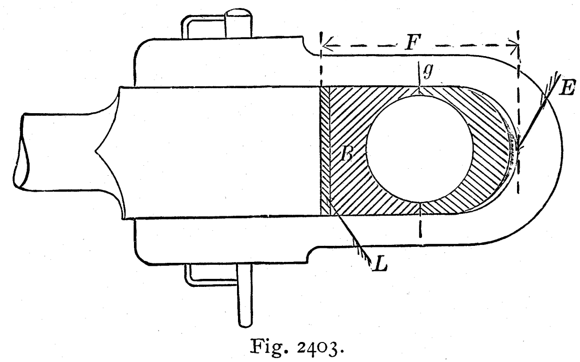

Fig. 2403.

centre of F and the centre of the oil-holes, and all that will be necessary will be to place behind D and B respectively a liner of sufficient thickness to bring the joint face of these brasses (D and B) even with the line *g*. To ascertain the thickness of liner necessary for this purpose, suppose the case of a rod end of the design shown in Fig. 2402, then, with the strap off the rod, drive the brass D down until its crown face beds fairly against the strap C, and with a scriber mark on the inside face of the jaw of the strap a line coincident with the joint face of the brass, then set the brass up the strap until its joint face comes fair with the centre of the oil-hole or the central line *g*, and then mark a second line so that on taking the brass out of the strap there will appear two lines, and the distance between these two lines is the necessary thickness of liner. In the case of the form of rod end shown in Fig. 2403, the process would be as follows: Let the strap have placed in it the brass B only, place it upon the rod, and set it so that it binds the gib and key, when the key is lifted up to its required position, then, with the brass B bedding fairly against the rod end, mark on the strap a line coincident with the joint face of the brass as before. Then move the brass in the strap until its face comes fair with the centre of the oil-hole or line *g*,

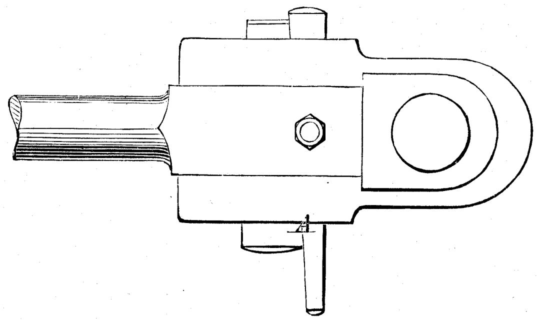

Fig. 2404.

and mark another line, and the thickness between these lines is the thickness of liner required at L.

If the brass is to be lined sufficiently to merely bring the key up without respect to the length of the rod we may drive the key home as in Fig. 2404, and mark on it a line coincident with the edge A of the strap. We then lift the key up to its proper height and mark a second line, so that when removed from the keyway the key will have on it the two lines shown in Fig. 2405, A being

Fig. 2405.

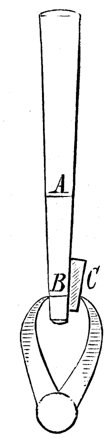

Fig. 2406.

the first and B the second line; and the difference between the width of the key at A and its width at B will be the thickness of the liner necessary to be placed behind the brass nearest to the key. To ascertain the precise amount of this difference (because a very small error as to this amount causes a great deal of extra labor), we set a pair of outside calipers to the width at A; and then passing the caliper points down to B, we keep one of the points even with the line B, and insert a wedge until it just fills

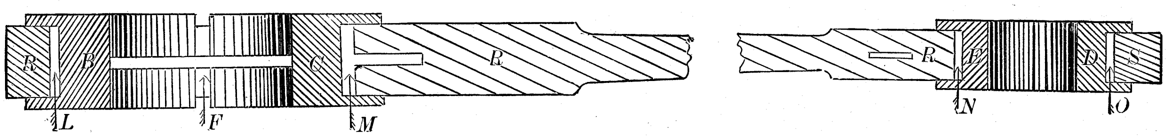

Fig. 2407.

the space between the other point and the side of the key, as shown in Fig. 2406, C being the wedge, which shou'd be chalked along its surface so that, when inserted until it touches against the caliper point, the latter will leave a mark on the wedge, denoting exactly how far the wedge entered, and hence the exact required thickness of liner.

It has thus far been supposed that the joint faces of the brasses are made to come brass and brass, that is to say, butt close together from the key pressure, when the brass bores properly fit the journal. Suppose, however, that the joint of the brass is left open as in Fig. 2407, and in that case a strip of metal F, whose diameter equals that of the journal, may be inserted between the brasses as shown, and at its centre should be provided a small centre-punch mark, denoting the centre of the bore. A piece of this kind should be inserted in the brasses at each end of the rod and placed in the middle of the length of the bore, the centre-punch marks being to apply the trammels to. Or if the rod was made of correct length when new, and the bore of the brasses, therefore, requires to stand central in space F, Fig. 2403, then

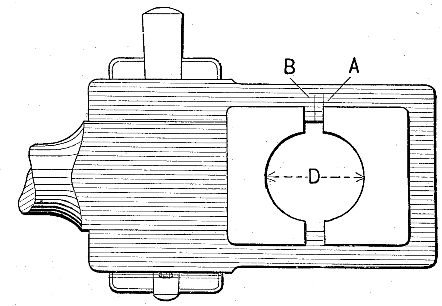

Fig. 2408.

the pieces F, Fig. 2407, may be dispensed with by marking a line B, Fig. 2408, central to space F, Fig. 2403. Then put the strap on the rod (with the brasses, gib, and key in place), and pull the strap back to hold the key up to its proper height.

The two brasses should then be placed as far apart as possible in the strap, each bedding fairly against its back or crown. Then, using the joint face of the back brass as a straight-edge or guide, a line should be marked on the side face of the strap, this line

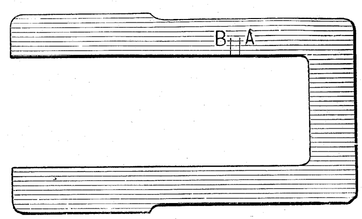

Fig. 2409.

representing the position of that face when the brass is bedded fairly home, and being shown in Fig. 2408 at A. This brass should then be moved forward until the bore of the pair of brasses at D, Fig. 2408, measures equal to the diameter of the journal (of the crank pin or of the cross-head pin as the case may be) and a second line B, also coincident with the joint face of the brass, should be marked upon the strap, and the strap will then have marked on it the two lines shown in Fig. 2409, in which it is shown removed from the rod; the distance apart of these two lines will be the thickness of the two liners combined, hence half this thickness will be the thickness necessary for each liner. Suppose, however, that it is not known whether the rod has been correctly made, and therefore it be unknown whether, in order to have the rod of the correct length, the brass bore should stand in the centre of the space or not.

This is often the case in repairs, and sometimes on new rods, in which slight inaccuracies of workmanship are apt to occur. In this case it is best to mark a line, as G, in Fig. 2410, representing at each end of the rod the centre of the space F in that figure. Then set a pair of trammels to the correct length of the rod, and with one point of the trammel resting on the point at the intersection of line C with line D (the latter being the line G transferred to the centre of the bore) at the small end of the rod, we mark a line at the other end. If the lines D are too far apart, making the rod too long, the trammels will mark a line R, and the distance between lines R and D at the large end will be the amount the rod is too long, while half this distance will be the thickness of liner to go behind each bottom brass if the error of length is to be equally divided between the two ends of the rod, in which case a line T, midway between D and R, must be marked, the trammel then being rested on T, and the line S marked. These two lines, S and T, are then the centre lines for the bores of the brasses.

If it is determined that one pair of brasses shall be central in its space F, all the error being thrown on the other pair, this may be done by lining one pair up so that its bore is true to line D, and putting behind the back brass at the other end a liner whose thickness is equal to the distance between D and R at the large end of the rod. It is obvious that the measurement for rod length must be taken on the line C.

Having thus determined what thickness of liner is necessary to bring the rod to its proper length, it remains to find the thickness of liner necessary for the other half brass, to bring the key up to its proper position, the process for which has already been explained. After, however, the various liner thicknesses have been found, and the sheet metal selected to cut them from, it is well to try if the thickness is correct by cutting off a small piece of the metal, putting it in place behind the brass, and then, after keying up the brasses, the rod length may be trammelled.

As the liners placed behind connecting-rod brasses require to be very finely bedded, the facility with which their forms permit them to be fitted is an important consideration.

In Fig. 2411 is shown the forms commonly given, the requisite form of liner being shown beneath each. Form 1 will bed very firmly to its seat, but it will be observed that its liner is a difficult one to make, the bottom section A being thicker than the sides or wings B. This is a troublesome form of liner to fit as well as to make. If it be made of wrought iron, the wings B must be either forged or filed to their reduced thickness.

In the form at 2 in the figure we have the same defect, while in addition the liner will not adjust itself so readily in position to its bed.

This latter is an easier form to make in the moulding pattern, and easier to mould, and somewhat easier to fit, but it is not so firm as the first. To cause this form of brass to bed easily to its proper position it is sometimes given a lug on the bottom, as at 3 in the figure, the lug extending part of the width across only, because if it extended fully across, the liner would require to be in two pieces, causing trouble both in fitting them and in getting them into their places. When the lug extends partly across, the liner must have a slot to pass over and admit the lug, and this causes trouble in bending the liner to the required curve.

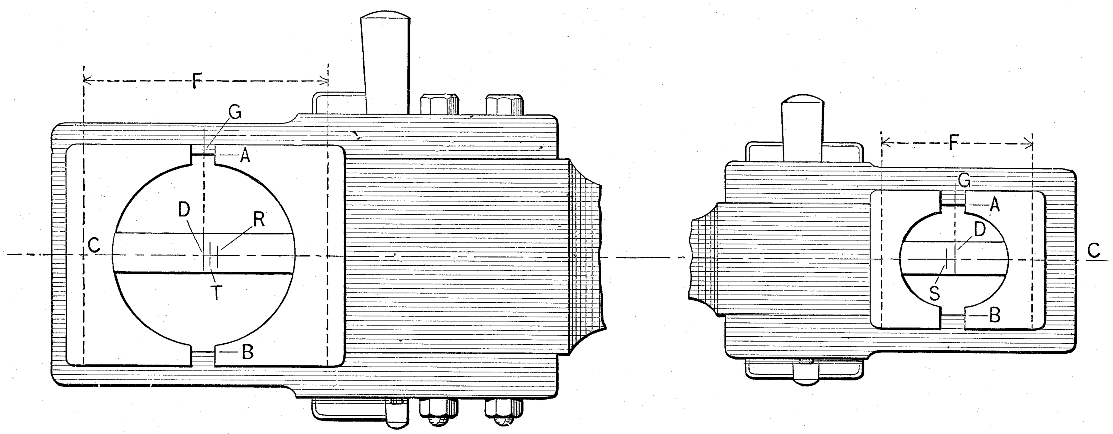

Fig. 2410.

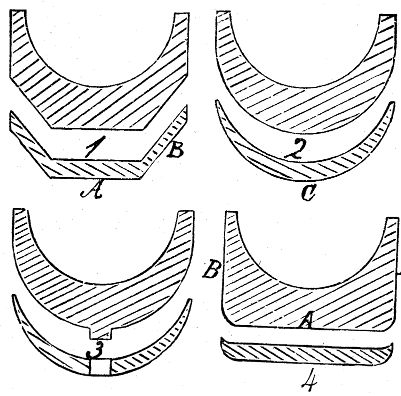

Fig. 2411.

In the form shown at 4 in the figure all these difficulties are avoided, while, if the lower corners are made square instead of rounding, a simple piece of sheet metal will serve as a liner requiring but little fitting and bedding if it be of the proper thickness.

To fit up a link motion, assuming the machine work to be done, the first thing to do is to face up the side faces of the links, making them parallel, and true to a surface plate. The slot is then filed out square to the side faces, its curve being filed to a template T, Fig. 2412, which is provided with a piece of wire for a handle. It is supplied with red marking, and is rubbed upon the slot to mark the high spots. The same template may be used to prepare the link block or die; but as soon as the block can be moved in the slot with slight hammer blows (using a mallet or a block of wood) it should be used instead of the template, the bearing marks serving to correct and finish the block as well as the slot. In filing up the block care should be taken to make it of even thickness on each side of its hole and with its sides parallel to the hole, the latter being of great importance. When the block is a sufficiently easy fit in the slot to permit it, a round stick of wood may be put through it and used to move it up and down the link slot for the marking process.

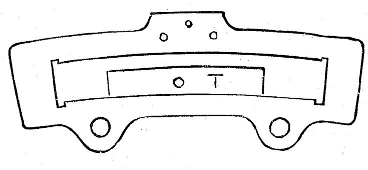

Fig. 2412.

The next operation is to fit the eccentric rod eyes to the link, and to then ream out the holes in both the link and the eyes while they are put together. The block may then be placed in the link, and the rocker pin passed through the block and into the rocker arm, so that the working fit of these parts when put together may be tested and adjusted if necessary. The link hanger may then be fitted to the saddle pin, when the whole will be ready for the file finishing and polishing, after which it may be case-hardened.

CASE-HARDENING.—Case-hardening consists in the conversion of the surface of wrought iron into steel, or in converting the grade of a low steel into a sufficiently high grade to render it capable of hardening. The depth to which this conversion occurs depends upon the material used to produce it, and the length of time the process is continued, varying from $\frac{1}{64}$ inch under the prussiate of potash process to $\frac{1}{16}$ or $\frac{1}{8}$ inch in the case of long-continued box case-hardening.

Work that is thoroughly case-hardened has a dull white, frosted-looking surface. If the surface of the work is mottled, or has patches of fancy water-mark colors, it may be hard, but it is not so to the highest attainable degree.

To thoroughly test this, take a new dead-smooth file and apply its corner edge under heavy pressure to the work on an edge where the fancy colours are, and then on an edge where the surface is white, and the latter will be found to be the hardest as well as hardened the deepest.

The simplest method of case-hardening is by the prussiate of potash process, for which it is essential that the prussiate of potash be finely powdered, and contain no small lumps. The piece being heated may then, if small, be dipped in the prussiate of potash, or if large have the same spread upon it. In either case, however, the work must be hot enough to cause the potash to fuse and run over the work surface, and this action may be assisted by using a piece of iron wire, spoon-shaped at the end, wherewith to apply potash to the work and rub it upon the work surface.

After the potash has thoroughly fused and run over the entire surface of the work it will usually have become somewhat cooled, and will require reheating before quenching in the water.

If this reheating be done in the blacksmith's fire, it is not well to put the blast on ; it is better to let the blast on gently while applying the potash to the work, so as to have a live clear fire to put the work in, and reheat it with the blast turned off.

While the work is in the fire it should be constantly rotated, not only to heat it evenly, but to let the adhering potash run over the entire surface, and as soon as the required heat is attained the work should be removed from the fire quickly and quenched in water.

It may be added, however, that if after the potash has been applied and fused more potash be added, so that it will adhere to the work and not fuse until the work is put into the fire a second time, then, after the work is quenched and taken from the water, there will be found on it a thick white and closely adhering fur of melted potash, and the work will be a dead white, with no fancy colors on it, and as hard as it is possible to make it.

The prussiate of potash process is, of course, from its expensiveness, both in material and labor, too costly for work to be done in quantities, and box-hardening is therefore resorted to.

In box case-hardening the work is case-hardened all over. It consists in packing the work in an iron box containing the hardening material, and subjecting the whole to a cherry-red heat for some hours.

A very common process is to fill a sheet-iron box with the work closely packed about with bone-dust, the pieces of the work having at least a thickness of $\frac{3}{8}$ths of an inch of bone-dust around them. The seams of the box are well luted with clay to prevent the gases from the consumed bone-dust from escaping, and to exclude air.

Various ingredients are used to effect case-hardening. One process is as follows : 20 lbs. of scrap leather and 15 lbs. of hoofs (cut into pieces of about an inch square), 4 lbs. of salt, and one gallon of urine are prepared, and a wrought iron box with a lid capable of being fastened on is obtained. The fastenings must be capable of ready unfastening when hot. A layer of leather and pieces of hoofs about $1\frac{1}{2}$ inches thick is first laid in the box, then a layer of salt, and then a layer of work. Leather and hoof are then packed closely around the work and above it for a thickness of about an inch, and a second layer of work added, and so on, the last layer being of leather, &c., completely filling the box ; the urine is then added, and the box well sealed with clay.

The box is placed in a furnace and kept at a red heat for about fourteen hours, and is then taken to a deep tank, and the work quickly immersed, so as not to be exposed to the air after the box is opened.

If the pieces are of solid proportions, so as not to be liable to bend or warp in the cooling, the contents of the box are simply dumped into the tank, the water being allowed to flow freely in the tank to keep up a circulation and cool the work quickly ; some work, however, requires careful dipping to prevent it from warping. Thus a link or a double-eye would be dipped endwise, a plate edgewise ; but all pieces should be immersed as quickly as possible after the box is opened.

Sheehan's patent process for box case-hardening, which is considered a very good one, is thus described by the inventor :

DIRECTIONS TO MAKE AND USE SHEEHAN'S PATENT PROCESS FOR STEELIFYING IRON.

No. 1 is common salt.
No. 2 is sal soda.
No. 3 is charcoal pulverized.
No. 4 is black oxide of manganese.
No. 5 is common black rosin.
No. 6 is raw limestone (not burned).

Take of No. 1, 45 lbs., and of No. 2, 12 lbs. Pulverize finely and dissolve in as much water as will dissolve it and no more—say 14 gallons of water in a tight barrel ; and let it be well dissolved before using it.

Then take three bushels of No. 3, hardwood charcoal broken small and sifted through a No. 4 sieve. Put the charcoal in a wooden or iron box of suitable size made water-tight.

Next take of No. 4, 5 lbs., and of No. 5, 5 lbs., the rosin pulverized very fine. Mix thoroughly No. 4 and No. 5 with the charcoal in your box.

Then take of the liquid made by dissolving No. 1 and No. 2 in a barrel as stated, and thoroughly wet the charcoal with the whole of said liquid, and mix well.

The charcoal compound is now ready for use.

A suitable box of wrought or cast iron (wrought iron is preferable) should next be provided, large enough for the work intended to be steelified.

Now take No. 6, raw limestone broken small (about the size of peas), and put a layer of the broken limestone, about $1\frac{1}{2}$ inches thick, in the bottom of the box. A plate of sheet iron, one-tenth of an inch in thickness, is perforated with $\frac{1}{4}$-inch holes one inch apart. Let this plate drop loose on the limestone inside the box. Place a layer of the charcoal compound, two inches thick, on the top of said perforated plate. Then put a layer of the work intended to be steelified on the layer of charcoal compound, and alternate layers of iron and of the compound until the box is full, taking care to finish with a thick layer of compound on the top of the box. Care should also be taken not to let the work in the box come in contact with the sides or ends of the box. Place a suitable cover on the box and lute it with fire-clay or yellow mud. The cover should have a quarter-inch hole in it to permit the steam to escape while heating.

The box should now be put in an open fire or furnace (furnace preferred), and subjected to a strong heat for five to ten hours, according to the size of the box, and the bulk of iron to be steelified. Remove the pieces from the box one by one and clean with a broom, taking care not to waste the residue, after which, chill in a sufficient body of clear, cold water, and there will be a uniform coat of actual steel on the entire surface of the work to the depth of $\frac{1}{16}$ or $\frac{1}{8}$ of an inch, according to the time it is left in the fire. The longer it is left in the fire the deeper will be the coat of steel.

Then remove the residue that remains in the box, and cool with the liquid of No. 1 and No. 2, made for the purpose with 20 gallons of water, instead of 14 gallons, as first used with the charcoal compound.

The residue must be cooled off while it is hot, on a piece of sheet iron or an iron box made for the purpose. Turn the residue into the supply box, and it will be ready for use again. The more it is used, the better and stronger it will be for future work.

There is nothing to be renewed for each batch of work but the limestone, and that, after each job, will be good burned lime.

A process used at the Elevated R.R. shops in New York city is as follows : The materials used are : leather, 1 part ; bone dust, 5 parts; salt, 1 part. Heat for 48 hours to a red heat in a box sealed with fire clay, and quench in a solution of 3 pounds of potash to 30 gallons of water.

The wrought iron thus treated is impervious to a new smooth file at a depth of $\frac{1}{16}$ of an inch.

The potash water is said to prevent both warping and the formation of blister marks on the work.

The durability of work case-hardened is greatly enhanced, but it is an expensive process; not so much by reason of the cost of

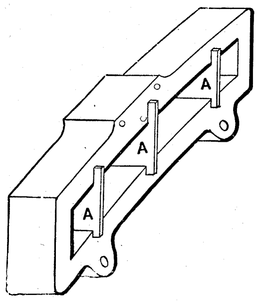

Fig. 2413.

it, but because it involves resetting and a refitting of the parts. The resetting is necessary because the work warps under or during the process. This warping can be prevented to some extent by placing the heaviest pieces in the bottom of the box, and so packing the same that the weight of the top pieces shall not tend to bend those beneath them when the hardening material has burned away, and so placing the upper pieces that they shall not be bent by their own weight. Thus both in

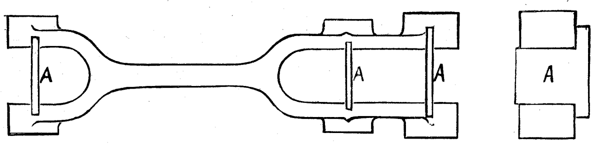

Fig. 2414.

packing and locating the work in the box the utmost care is necessary.

SETTING WORK AFTER HARDENING IT.—Work that has been hardened or case-hardened usually swells during the hardening process, and therefore requires refitting afterwards. This swelling usually occurs in all directions, thus holes and bores become of smaller dimensions, while the outside dimensions also increase, bolts become of larger diameter and sometimes increase in length.

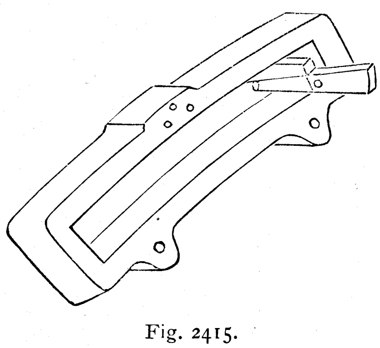

Fig. 2415.

In very exceptional cases, however, the dimensions of a piece of work will not alter.

This renders it usually necessary to refit the work after it has been hardened, thus holes which are ground out by laps or bolts may be ground to diameter in a grinding lathe.

In some practice, however, the work to be hardened is made a somewhat too easy fit, the holes tapped out and the bolts ground in by direct application of the bolts to their holes in connection with flour emery and oil. This latter plan is also adopted for

forms not easily ground out in a machine, as, for example, a die in a link of a link motion.

To prevent surfaces or forms of this class from altering their shape or dimensions during the hardening process, slips of iron are sometimes fitted to them before they are placed in the hardening box. Thus Fig. 2414 represents a double eye, and Fig. 2413 a link having thin pieces fitted in as shown at A in both figures.

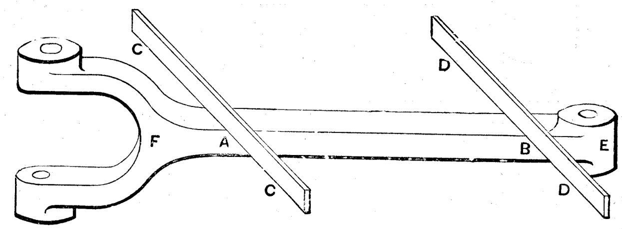

Fig. 2416.

The heating for the hardening process is also apt to impair the alignment of the work, causing it to require resetting by the aid of parallel strips and straight-edges.

The faces of the link having been set, the width of the link slot must be set, for it may open or close in places. If it opens it may be closed by the jaws of a powerful vice, while if it closes it may

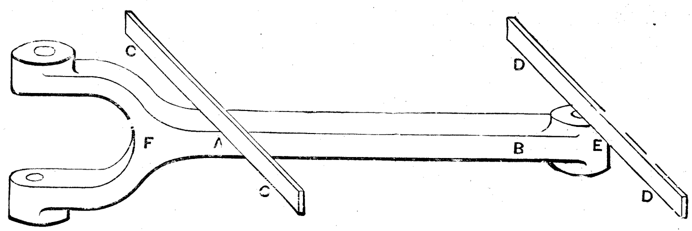

Fig. 2417.

be opened by a pair of inverted keys, inserted as shown in Fig. 2415, and driven in by the hammer. At each trial, however, a mark should be made on the driven key, so that it may be known how far to drive it at the next trial.

Fig. 2416 represents a link that is supposed to have been case-hardened, and to therefore require resetting. The stem

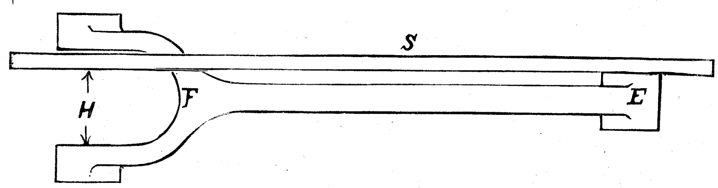

Fig. 2418.

from A to B should first be straightened to a straight-edge on both its side and edge faces. It should then be tested for winding with the winding strips, C, D, placed as in Fig. 2416, and then as in Fig. 2417.

To test the alignment of end E, press a straight-edge S fair against its side face, as in Fig. 2418, and measure the distance

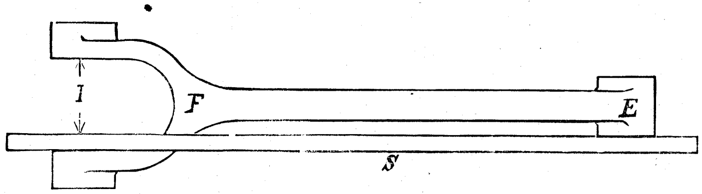

Fig. 2419.

H. Then place the straight-edge on the other side face of E and measure the distance I, Fig. 2419, and these distances both measuring alike, E will be true providing that the jaws at end F have not altered from their proper width apart.

To test the alignment of the jaws at end F, press a straight-edge against the outside face of the hub and measure the distance J, Fig. 2420, then apply it on the other side and measure distance K, Fig. 2421, and when distances J and K are equal and the width L between the jaws is correct, end F is in line in one direction. To test it in the other direction, apply a pair of

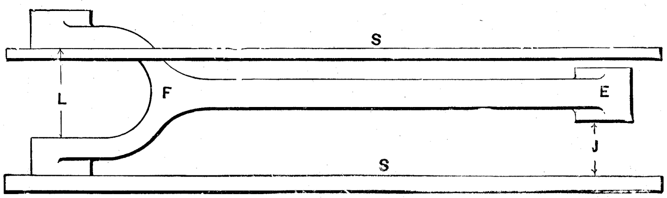

Fig. 2420.

parallel strips, placing one on end E as in Fig. 2417, and the other across the face of the hub of end F to see if there is any twist.

Suppose, however, that distances J K are unequal, then if

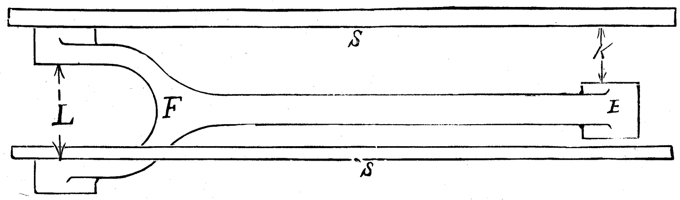

Fig. 2421.

distance L is too narrow (when tested by the piece that fits between the jaws) then the jaw at F that gives the widest distance at E is the one that requires correction, or if distance L is too

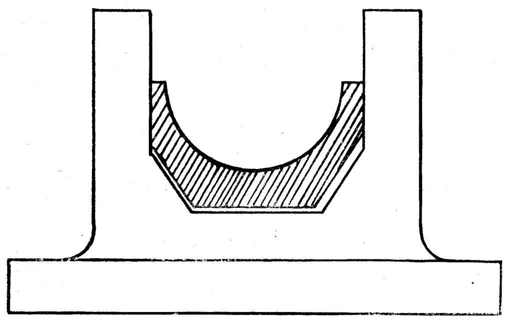

Fig. 2422.

wide, the jaw that shows the least distance at end E is the one requiring correction.

The link should be warmed to about 300°, or nearly *black* hot, and pieces of sheet copper placed between the work and the

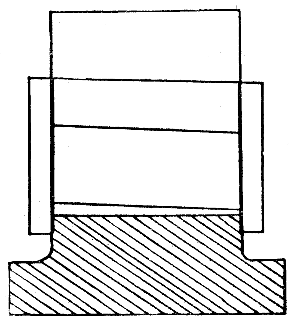

Fig. 2423.

anvil, and between the blacksmith's tools and the work, so that the latter may not be bruised by the blows delivered to effect the straightening.

After the process has been performed at each end individually the testing should be repeated, because setting the end F may have impaired the setting of end E, in the alignment to F.

It is obvious that the same setting or aligning process would be required in the case of a large link, where the ends were forged separately and welded to the body after the machine work and fitting had been done to them.

FITTING BRASSES TO BOXES OR TO PILLAR BLOCKS.—In the operation of fitting brasses to their boxes or to pillar blocks there are two things to be especially guarded against: First, having

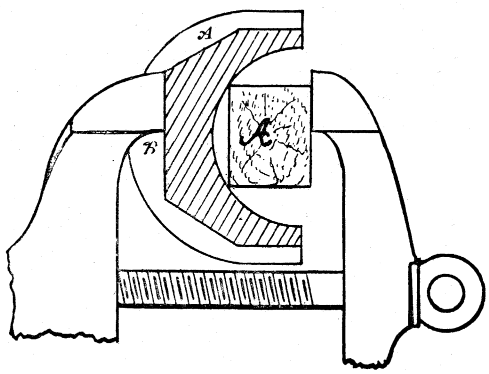

Fig. 2424.

the brass let down one-sided, as shown in Fig. 2422; and next, aslant, as shown in Fig. 2423. The first depends on taking the proper amount off the two side faces, and the second in cutting the inside of the flanges fair. To cut the side faces fair, grip the brass in the vice, as shown in Fig. 2424 (the brass being shown in section), in which A is a block of wood. Take the measure of the box, down where the brass will come when home,

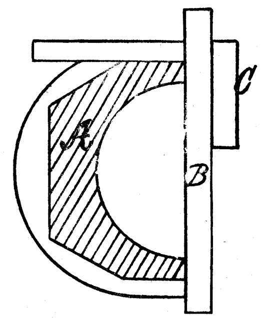

Fig. 2425.

and, if there be any taper to the box, set the inside calipers to the top of the location for the brass, and after the brass is in the vice place a square under one side-face, as at B in Fig. 2426, and see how much there is to come off. This saves the use of outside calipers, and is better because, not only is the trouble of setting the latter avoided, but the inside calipers can be tried to the box

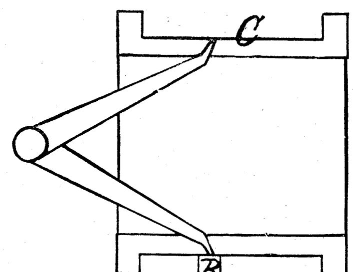

Fig. 2426.

and the work in an instant, and a correction can at once be made if the calipers have got shifted. The cape chisel, or cross-cut, as it is sometimes termed, should first be used, taking a cut close to the flange, and making it half as deep as the calipers (applied as shown in Fig. 2426) show there is metal to come off. Then a similar cut should be taken close to the other flange, especial care being taken to take both cuts equally deep, and leaving as much to come off the other side face of the brass; otherwise, the brass will come atwist. Then take a straight-edge, and, placing its edge fair with the two chisel-grooves, while holding it firmly against the joint face of the brass, mark a line running from one chisel groove to the other; this line serving as a guide for the depth of all the other cape-chisel grooves. Now cut off the intermediate spaces with the flat chisel, using a straight-edge as a guide. If the box is taper, chip the side face to a corresponding taper, using a bevel-square, or estimating the amount by the eye if it is not too much. Now file the chipped surface flat and true, and then turn the brass upside down, gripping it with the wood as before, and dress the other side face (applying the inside

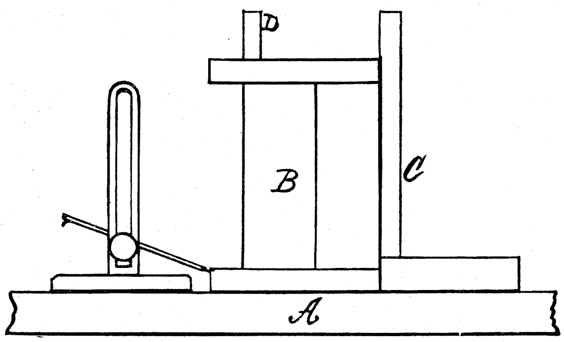

Fig. 2427.

calipers as in Fig. 2426), and bring that face down to within about $\frac{1}{64}$ inch of the size to which the calipers are set. If the block of wood is made a little shorter than the length of the brass, the calipers can be applied without moving the brass from or in the vice. The method of applying the square to these side faces is shown in Fig. 2425, in which A is the brass in section, B a straight-edge, and C a square.

We now turn our attention to the flanges, and apply a square to the crown of the box, bringing the edge of the blade fair with the edge of the box, as shown in Fig. 2428, A representing the box in section, and B the square. Supposing the crown of the box to stand square, as shown in the engraving, and as it should do, we set the brass upon a truly-surfaced iron plate and square

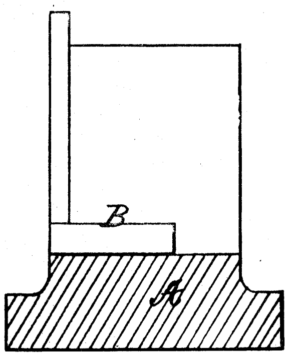

Fig. 2428.

up the joint face, as shown in Fig. 2427, in which A is the surfaced iron, B the brass, and C the square. Since, however, the joint face of the brass may not be parallel with the crown face, we may place the square so that its blade edge comes fair with the crown face—that is, as shown at D in Fig. 2427—and set the brass crown (by means of inserting a wooden wedge under its face) truly perpendicular or parallel with the square blade edge. Now try the square with the side face of the brass, setting the latter true with the square blade, as in Fig. 2430; A being the iron plate and B the square; and, supposing the box to be true, as it usually is, we may set a scribing-block, as shown in Fig. 2427, and mark off how much is to come off the flanges by scribing a line around the flange, sufficiently depressing the scriber-point to allow an equal amount to come off each of the flanges. Sometimes, however, the inside faces of the box are not true with the outside face. To test this, we place a straight-edge across the outside face, place a square on it, and apply it to the inside face of the box, as in Fig. 2429, which is a plan view of the box, A being the straight-edge and B the square. If the square thus applied shows a want of truth in the box, we may set the brass over when adjusting it (as in Fig. 2427) to a corresponding amount, and thus mark off the flanges to suit the box.

To hold the brass while operating on the flanges, we resort to

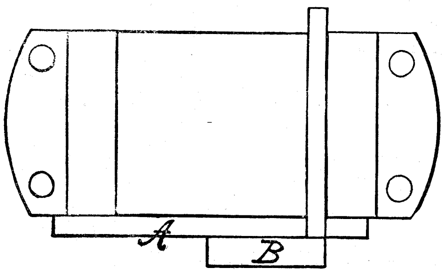

Fig. 2429.

the device shown in Fig. 2431, in which A is a bolt, B the brass, C a piece of hard wood, and P a clamp fastened down by a nut D. To sustain the plate P, so that it shall not fall down on the piece of wood every time the brass is taken out to try it in the box, we may insert the spiral spring S, shown in the separate view of the bolt, nut, and plate. One such holding device will do for different

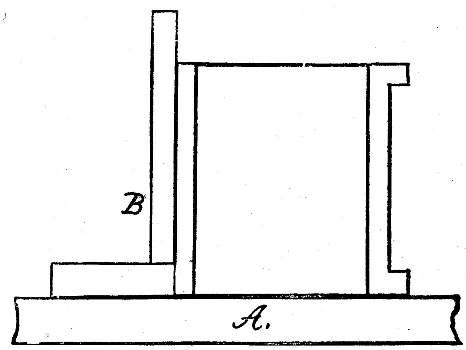

Fig. 2430.

sizes of brasses, by either gripping the bolt lower down in the vice jaws or putting washers between the nut and the plate. This will hold the brass very firmly, and at the same time leave the whole of the flange easily got at. When the flanges are dressed, we may try the brass in the box, putting red-lead marking on the box to mark where the brass binds. While letting the

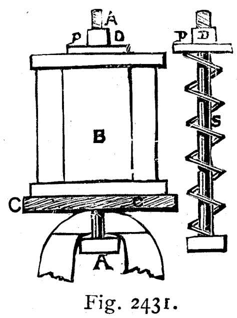

Fig. 2431.

brass down, however, we must be careful to let it down fair, to avoid the state of things shown in Figs. 2422 and 2423. A ready method of doing this is (supposing the box to be true, as it should be, and making the necessary allowance if it is not), to set a pair of inside calipers to the joint face of the brass and the top of the box, as shown in Fig. 2432, trying the calipers (in the two positions there shown) on both sides of the box. This should be done every time the brass is tried in the box, until such time as the brass begins to bed against the bottom of the box.

We now come to the bedding of the brass to its seat in the box. This requires skillful treatment; for one mistake will involve a great deal of extra work to rectify it.

In fitting the brass to the box care must be taken to leave it a rather tighter fit to the box than it requires to be when finished, that is after the bore has been made, because in the boring operation the sides of the brass are apt to close and loosen the fit of the brass to the box.

When the side faces and flanges are so far fitted as to render probable the brass driving home at the next trial, the bed of the box should be given a coat of red-lead marking, and small pellets of stiff red lead or putty should be stuck on the bottom of the box, two at each end of each bevel, and two at each end of the bottom, with one in the middle of the bottom and each bevel, as shown at

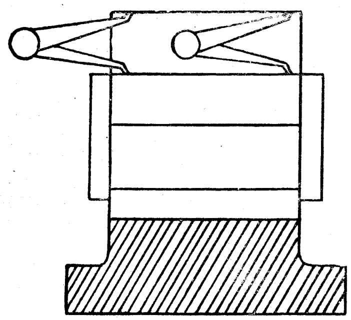

Fig. 2432.

A, B, C, D, E, F, in Fig. 2433, by the black spots. Then when the brass comes home, it will flatten these pellets, and their thickness (when the brass is taken out) will show how much the bevels are out, and how much to take off the brass to make it bed. These pellets *must* be restored to their original shape every time the brass is tried; otherwise, they may mislead. To insure their sticking to the box, and not coming out with the brass, the bottom of the box must have red-lead marking kept upon it. The chipping should continue until the pellets flatten out equally on the two bevels, but are left a little thicker on the bottom. If this is not done, the bottom will bed first, causing a great deal of extra filing, because filing the side bevels will let the bottom down too far.

In driving the brass in and out of the box while fitting it, a

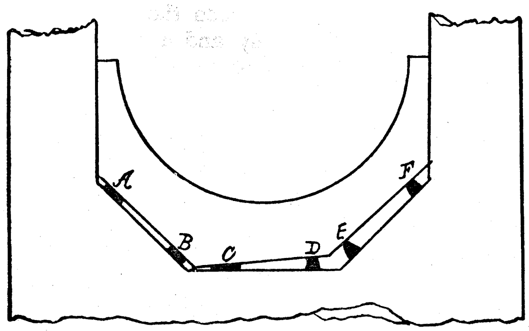

Fig. 2433.

piece of wood must be used to strike on, otherwise the brass will stretch during the fitting and come loose in the box during the boring.*

The patterns from which the castings for brasses are moulded should not be made of the same angle or sweep on the bedding part or bottom as the bottom of the box, pedestal, or pillar block, because the brass casting, in cooling in the mould, contracts across the bore; thus if in Figs. 2434 and 2435 the full lines denote the shape of the pattern the dotted lines denote the shape the casting will be.

The result of this is that when the brass is let down in the box it will bed on the crown and not at the sides. Thus in Fig. 2436, A is a pedestal, and B a brass which beds at C, but not at D or E. In Fig. 2437 is shown an example of a brass, with a circular bottom, which would bed at the crown C, but not at the sides D E, until the metal was cut down to the dotted circle F.

The amount to which this contraction in the mould occurs varies with the size of the brass, the difference in the thickness at the crown and at the face joint, the composition of the metal of

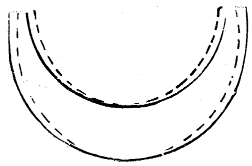

Fig. 2434.

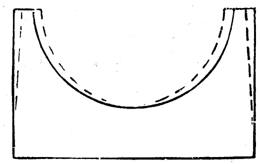

Fig. 2435.

which the casting is made, and the temperature of the metal when poured into the mould. It should always be allowed for, however, for the following reasons. Referring again to Fig. 2436, it will be noted that it requires a heavy cut off C to bring E,D to a bearing, while it is apparent that if the brass met the box at E,D before it did at C, but little filing at E,D would let the brass down a long way. It saves work, therefore, to so make the pattern as to insure that the brass casting shall have bedding contact at D

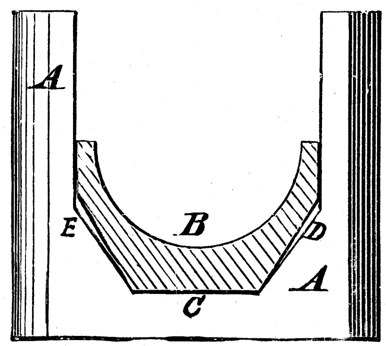

Fig. 2436.

and E before it does at C. As an example of the allowance to be made for this purpose, it may be stated that in brasses of 6 inches bore and 9 inches long, the hexagon of the brass pattern at D,E, Fig. 2436, would require about $\frac{1}{16}$ inch put on them to compensate for the contraction, supposing that the hexagon on the brass pattern were made at first to fit the hexagon of the pedestal or axle box.

To originate a true flat surface we proceed as follows: In the absence of a standard plate to go by, we must have three

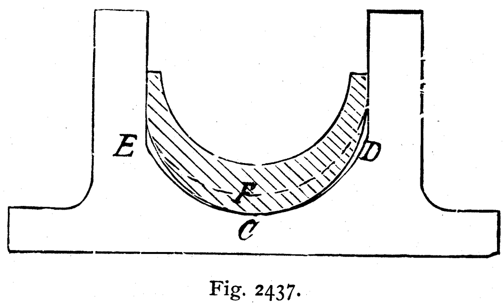

Fig. 2437.

plates, and one of them must be accepted as a provisional or temporary standard. This we will call No. 1, and we fit Nos. 2 and 3 to it and then try them together, and if they also fit it is proof that No. 1 was true, and that all three are therefore true. It will very rarely happen, however, that this is the case; but Nos. 2 and 3 merely serve to show how much No. 1 was out of true.

Suppose, for example, that No. 1 is concave in its length, and we fit No. 2 to it, as in Fig. 2438, and then fit No. 3 to it as in Fig.

* See remarks on Pening, p. 162.

2439, and when we come to put Nos. 2 and 3 together, as in Fig. 2440, we find that they are out of true to twice the amount that No. 1 is, and that all the work that has been done to them to fit them to No. 1 has been thrown away, and possibly to make

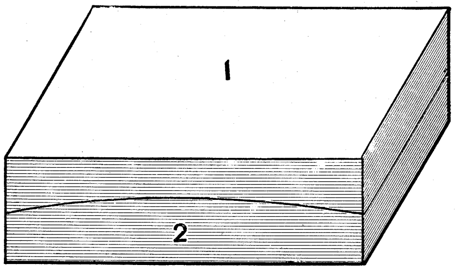

Fig. 2438.

them worse instead of better. It becomes important therefore to select the most true plate for No. 1, and this we may do as follows:—

If we have a straight-edge that is known to be true, we may

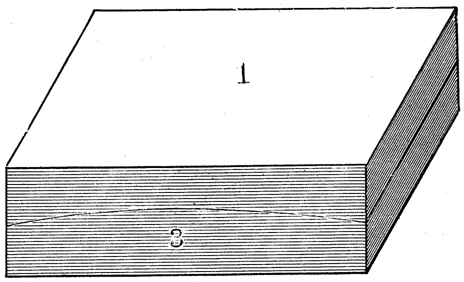

Fig. 2439

lay it on the face of a plate and move it laterally from each end alternately, and if it swings from the centre the plate face is rounding, while if it shuffles across moving first at one end and then at the other the face is hollow; but if it glides as it were

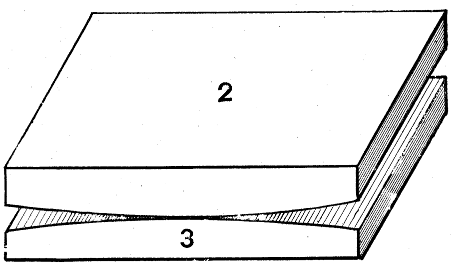

Fig. 2440.

across, the surface is nearer true. The straight-edge must not be pressed to the plate, but merely touched laterally to make it move laterally, for if we take a true straight-edge and press it vertically to a true surface while moving it, it will show the marks

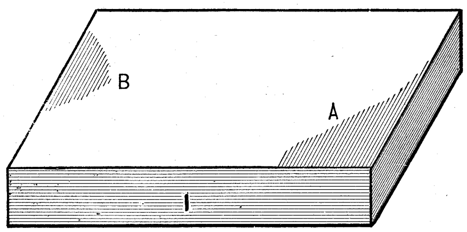

Fig. 2441.

of contact the most plainly immediately beneath the parts where it is pressed. Selecting by this means the two plates that appear to be the most true we proceed to test them further as follows: We give to one of them which we will call No. 1 a light coat of red marking, and placing it upon the other or No. 2, we move it about in all directions and then take the two apart to examine the bearing marks. Suppose then that No. 1 shows the bearing marks to be at the shaded places, A and B, in Fig. 2441, while the bearing marks on No. 2 are as at the shaded parts A and B in Fig. 2442, the two ends A having been placed together;

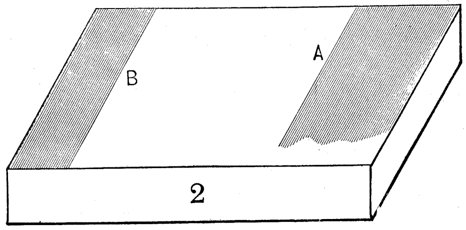

Fig. 2442.

then we know that B is a high spot on No. 1, and A a high spot on No. 1 for the following reasons. The marks at A, No. 2, have been made by the marking at A on No. 1, and will extend across No. 2, a distance depending upon how much No. 1 has moved across No. 2, for if corner A of No. 1 had only moved half-way across No. 2, it could only have marked half-way across it.

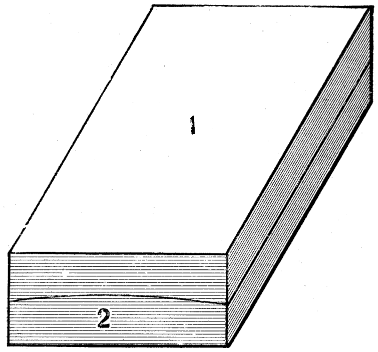

Fig. 2443.

Similarly spot B on No. 1 has marked spot B in No. 2, because it has been moved all the way across, it being evident that the marking on B, No. 1, can only mark plate 2 as far across its width as it is moved across it. From this it follows that the higher or more prominent a spot is the less will be the area of the bearing mark at that spot.

Now suppose that the two plates were curved to an equal

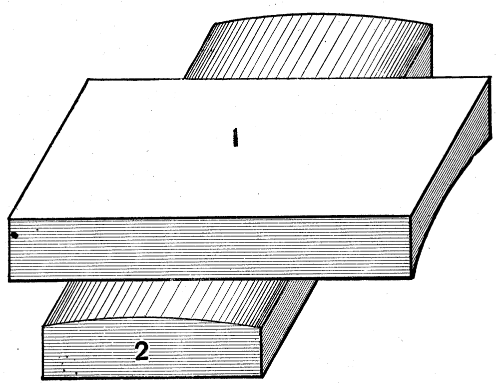

Fig. 2444.

degree as in Fig. 2443, and the bearing marks would extend all over both surfaces; but we may discover this error by turning one plate at a right angle, as in Fig. 2444, in which case the bearing marks would show along the edges of No. 1 and along the middle of No. 2, and we may correct each with the file until both plates mark all across and from end to end when tried together lengthways as in Fig. 2443, and one across the other as in Fig. 2444.

But the plates may be curved to a different degree, as in Fig. 2445, and it then becomes necessary to know which to file the most in correcting them and fitting them together, which we may discover as follows :—

We give one plate a light coat of red marking and rub it upon the other both sideways and lengthways. Suppose that on being separated and examined the bearing marks, shown as at A A and B B, Fig. 2446, on one plate, and at C C and D D, Fig. 2447, on the other, and as those at A A and B B are the narrowest, or in other words extend the least distance across the plate, it is proof

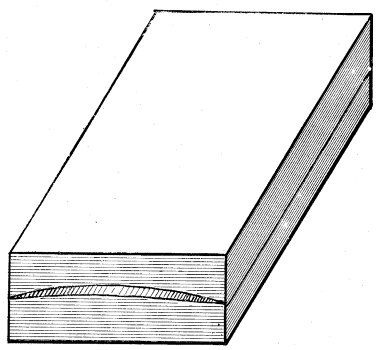

Fig. 2445.

that this plate is more concave than the other plate is convex, and therefore needs the most correction. This is plain because whatever part of a plate touches another, will, if the two are merely pressed together, only leave a bearing mark equal in area to itself, while this area will obviously be increased in proportion as one plate is moved about upon the other.

When the object is to merely produce a flat surface, independent of the thickness or parallelism of the plate, it is not always necessary to file or scrape the whole of the area showing bearing marks. Suppose, for example, that the marks appear as in Fig. 2448, and as the bearing marks at A A show that edge of the plate to be straight already, all that is necessary is to ease the surface at B in order to let that side of the plate come up.

When we have fitted two of the three plates together we must accept one of them as a true one and (calling it No. 1) fit Nos. 3 and also 2 to it, and then try Nos. 2 and 3 together. If these require correcting the amount of correction must be made equal

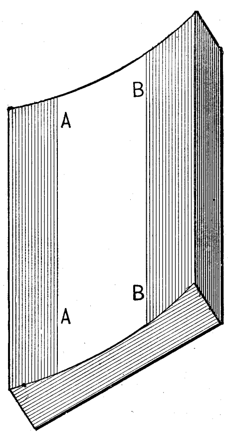

Fig. 2446.

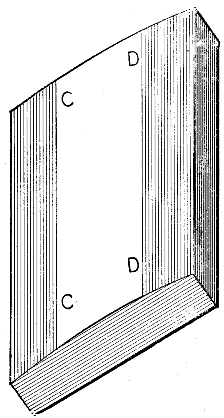

Fig 2447.

on each, and when this is done we must accept one of these two (say No. 3) as the standard, fit No. 1 to it, so that Nos. 1 and 2 both having been fitted to No. 3 may be tried together and both corrected equally ; nor will the surfaces of any of them be true until all three will interchange in this manner and show a perfect contact.

It is to be noted, however, that in this process we have not altogether eliminated the error due to the deflection of each plate. Suppose, for example, a plate to be resting on its feet and its middle will sag or deflect to some extent (very minute though it may be in a small plate), and when we place another plate upon it the latter will also sag or deflect if its points of contact are far apart, and in any event the truing is performed by the bearing-marks, which the operator knows show the darkest and the brightest where the contact is greatest ; hence by the time the contact marks show equally strong all over, the top plate will have been fitted to suit the deflection of the lower one. Since, however, the nearer the points of contact (between the plates) are together the less the degree of deflection, it is better in trying them to place the test plate on the top of the one being operated on. If the plates are long ones it will not answer to have more than three points of rest for the lower plate, unless the foundation on which the plate rests is made so true that each resting point of the plate will bear with equal pressure on the foundation plate or stone.

To eliminate as far as possible the deflection, the three plates may be got up by the process described, and then finished by trying them when resting on their edges (the trued surfaces standing vertical), interchanging the three plates as before.

In this case the surface will be true when standing vertical as finished, but there will still be some untruth from deflection when the plates are rested on their feet, though it will be less in amount than if the plates were finished on their feet as first described.

In finishing surface plates with a hand scraper, we have a surface that bears in fine spots only, these spots being the tops only of the scraper marks. Now the depth of the scraper marks

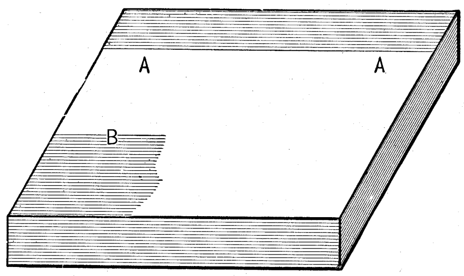

Fig. 2448.

are unequal, because immediately after the scraper is sharpened it cuts the easiest and the deepest, the scraper cutting less deep as its edge dulls. The operator regulates this to some extent by applying a greater pressure to the scraper as it gets dull, but from differences in the texture of the metal and from other causes it is impracticable to make the scraper cut equally deep at each stroke, as a result the tops of the scraper marks, which are the points of contact of the plates, wear away quickest, and the plate soon loses, to some extent, its truth.

Again, work that is so small as to cover part of the plate surface only, wears the part of the plate to which it is applied, and although the careful workman usually applies small work at and near the outside edges of the plate only, still these are all elements tending to produce increased local wear and to throw the plate out of true.

To obviate this difficulty the surface should be got up to bear all over, thus greatly increasing its bearing area and proportionately decreasing its wear. To produce such a surface the following plan was adopted by the author in 1876.

The filing process was continued with fine Groubet files, and testing the plates, rubbing them together sufficiently to mark them without the use of oil. Very short file strokes must be employed, and great care taken to apply the file to the exact necessary spots and places.

Then instead of using the scraper, No. 0 French emery paper was used, wrapped over the end of a flat file. The plates being interchanged and trued with No. 0, No. 00 was used, and the testing and interchanging repeated. These grades of emery paper were then wrapped or folded over the curved end of a piece of wood, the plates interchanged and rubbed together as before, and the emery paper used as described for the scraper. Subsequently Nos. 000 and 0000 French emery paper were similarly applied until the plates were finished. Much assistance to this method may be rendered by taking a piece of Water of Ayr stone, and truing its surfaces by rubbing them on the plates after the fine filing and before the emery papering. Then while applying the finer grades of emery paper the stone may be rubbed (with oil or water) in various directions over the surface. This has the effect of wearing off the very fine protuberances due to the emery paper cutting the metal most around its pores, and furthermore it causes the marks made in testing to show more plainly.

In skillful hands this process very far surpasses, both in the superiority of its results and in rapidity of execution, the scraping process, leaving a brilliant polished surface, so smooth that it feels as soft as satin, and the contact becomes so complete that no bearing marks can be distinguished.

In this process great care must be taken in cleaning the surfaces before applying them together, as the finest particle of dust will cut scratches, which though imperceptible on scraped surfaces, appear very coarse and deep on these smooth ones.

The amount of metal taken off by the finer grades of emery paper is so small as to be scarcely appreciable, save that it slightly discolors the emery paper.

The finest test for plates finished in this way is to rest the lower one quite level, clean it with alcohol, wipe it clean with old linen rag and finally with the palm of the hand, which if quite dry is more effective than anything else. The eye should carefully sight the plate surface with the light reflecting on that surface, when particles too fine to be felt may be observed and wiped off with the hand. In dry weather it is a difficult matter to clean the plates perfectly, as while one is being cleaned the fine particles of matter floating in the air rest upon the other; but in rainy weather the cleaning is much easier.

The plates being cleaned one must be lowered vertically on the other where it will float, there being a film of air between the two which it is almost impossible to exclude by pressure even though the plates be moved while pressed together.

If under these conditions the surfaces are not true and the top plate be set in motion in various directions, by a light finger touch it will swing round, the parts of the surface most in contact being the centre of motion. Suppose then the top plate to swing from one end it should be turned end for end on the bottom plate, and if the location of the centre of motion is still at the same end of the top plate, that plate is high there, while if the centre of motion in both cases is at the same end of the bottom plate it is the one that contains the error.

If the top plate swings upon its own centre of motion it must be moved farther off the bottom one, first on one side and then on the other, to discover if it or the bottom plate is in error; while if the top plate swings first from one end and then from the other, one or both of the plates are hollow and the top one must again be moved farther off the lower one, and the test by motion continued. The error discoverable in this way is very much finer than can be discovered by the marks of contact, since a plate showing quite even contact when quite dry and clean, and tested as lightly and carefully as may be will show error by this motion test. The error being so small in amount that it may be corrected by rubbing the plate with rag and oil, applied under hand pressure to the plate.

To cause the plates to bind together so that rubbing one on the other will leave contact marks, the top plate must be placed about an inch over the corner of the bottom one, pressed closely to it and forced laterally over it. A pair of plates of the Whitworth pattern (such as shown in Fig. 2449) placed by the author in the Centennial Exhibition, required, when put together dry as above, $341\frac{1}{2}$ lbs to *slide* the top one over the other, which was due to the friction caused between the surfaces by the atmospheric pressure acting on the back surface of the plate, the latter having a superficial area of 12 by 8 inches.

Here it may be added that a plate of the same dimensions, and having its surface finished simply by filing with a dead smooth file, which plate was made for exhibition at a lecture on hand work, delivered before the Spring Garden Institute of Philadelphia, required a force of 22 lbs. to slide on the one on which it rested.

If two plates finished by the above method be placed together by sliding one upon the other it will be found that with the hands applied as in Fig. 2449, they can be separated or pulled apart with less force than it requires to slide one upon the other, because the plates bend and unlap, as would be the case if two sheets of paper were wetted and placed together and then taken apart by pulling two edges in opposite directions. But if the power to pull the plates apart be applied at the middle of the plate it will require a much greater force to separate them, although how much is problematical, no experiments having been made upon the subject. Furthermore the friction between two such plates will be greater if the surfaces be lubricated than if quite dry.

Thus, with the surfaces cleaned by alcohol, the top plate will move comparatively easily, but if the surfaces be slightly oiled and then wiped apparently quite clean with old dry rags, the friction will be a maximum. If then a piece of rag, say of an area of an inch, have one drop of oil upon it and be then applied to the surfaces of two plates after they have been cleaned with alcohol, the friction will still be about 3 lbs. per inch of area of one plate. With the surfaces well lubricated it will still require more power to slide one plate upon the other than would be the case were both plates quite dry.

The reason of this is that when quite dry it is impracticable to exclude the air from between the surfaces, whereas with the lubrication the air is more perfectly excluded and the atmospheric pressure forces the plates together.

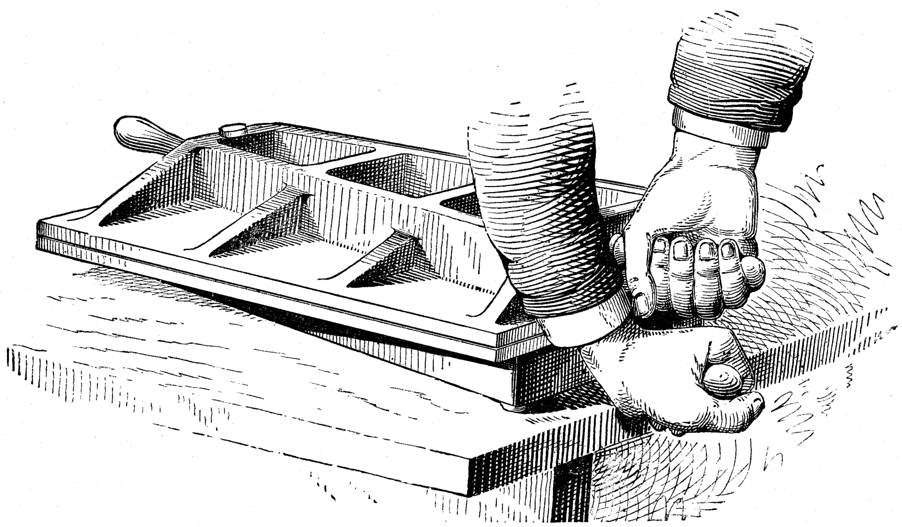

Fig. 2449.