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"PRACTICAL SETTING OF LOCOMOTIVE VALVES"

BY

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The object of this paper is to outline the method of setting locomotive valves to designers' requirements. It is not intended to consider the question of design.

The Author assumes that members are already acquainted with the lay-out of a locomotive gear, so will just briefly refresh their memory with a few definitions.

Steam Lap, When a slide valve with outside admission is placed centrally over the steam ports, the distance the valve overlaps the steam port on the live steam side is called the steam lap or outside lap.

Exhaust Lap is the amount the valve overlaps the steam port on the exhaust side, when the valve is in its central position.

Exhaust Clearance is the distance between the edge of the valve on the exhaust side and the nearest edge of the steam port, when the valve is placed centrally.

Lead is the amount of port opening to steam when the piston is about to commence its stroke.

Angular Advance is the angle the eccentric sheave has to be moved to overcome the steam lap, plus the angle it is moved through to give lead.

Direct Motion. When the valve and link move in the same direction at all times the motion is said to be direct.

Indirect Motion is where the valve and link move in opposite directions.

An eccentric sheave may be considered as a small crank, and the distance from the centre of the axle to the centre of the sheave is the eccentricity of the eccentric. The travel of the valve is equal to twice this amount. In the method of valve setting to be described, the eccentric sheave is keyed to the axle before the wheels are put under the locomotive. This is done by setting the R.H. crank of the driving wheel upright by means of a double plumb-bob. When the distances from each string to edge of circle where axle enters the wheel have been equalised, the crank is in its correct position. Next place the template on the axle and when the spirit level (which is incorporated in the template) shows level, the key-way of the eccentric sheaves can be marked on to the axle.

Stephenson's Gear.

With open rods the lead is increased as the link moves nearer mid gear. With crossed rods lead is decreased as link moves nearer mid position. In mid position no steam can get into the cylinder as the valve entirety closes the ports.

The charts in Fig. 1 are taken from "Link Motions and Valve Gears," by F. H. Colvin, Associate Editor "American Machinist." The charts show exactly what happens under different conditions. Chart A shows reverse lever in full gear, D, valve, 1″ lap, 1/16″ lead at full stroke and 6″ travel, with exhaust line and line. The steam port is open 1/16″ at beginning of stroke. The solid curved line shows how quickly the valve opens, and when the piston has reached just over 1″ of its stroke the valve is fully open. At 18″ of piston stroke it commences to close, and at $21\frac{3}{4}$″ cuts off. Exhaust opens at $23\frac{1}{4}$″ and is nearly wide open at the end of the stroke, and continues wide open until the piston is within 3″ of its return stroke, where it begins to close, and at $\frac{3}{4}$″ of the stroke it closes. This gives very little compression, but little is needed as piston speed should be slow.

In Chart B, hooking up to cut-off at 12″ or $\frac{1}{2}$ stroke the lead is increased to $\frac{1}{4}$″ and the valve travel reduced to 3″. At 2″ of stroke the valve is fully open, at 4″ it commences to close, and cuts off at 12″. Expansion continues until the piston reaches

19 ⅝″ when the exhaust begins to open, reaching full opening at end of stroke. Exhaust begins to close where shown and finally closes at 5″ from end of stroke, thus giving more compression, which is necessary since piston speed is higher.

Hooking up to cut off at 6″ or $\frac{1}{4}$ stroke (Chart C), lead is increased to 5/16″ and valve travel is only $2\frac{1}{2}$″. At 1″ piston travel the valve is open its greatest amount, ⅜″, and immediately commences to close, cutting off at 6″. Exhaust opens at 16″ and is fully open at end of stroke, begins closing at 2″ of return stroke and finally closes for compression when within 9″ of return stroke.

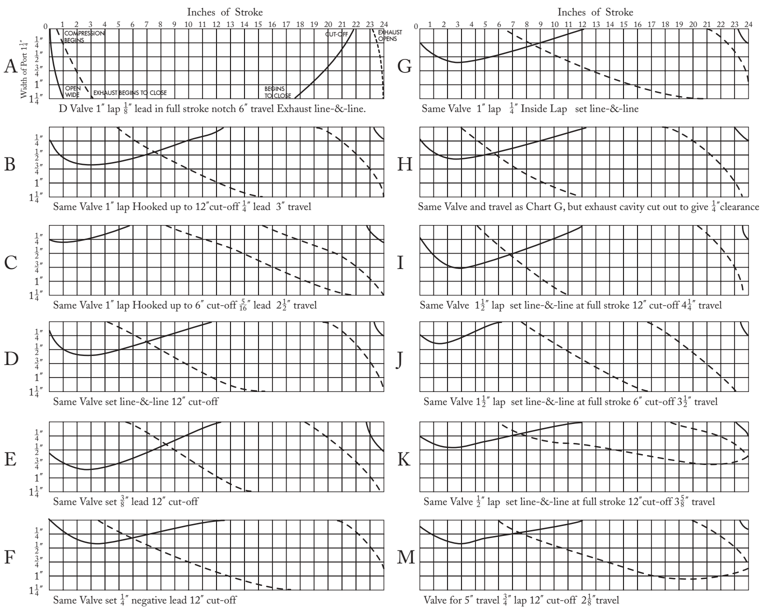

FIG. 1.

Pre-admission, or admission of steam before piston reaches end of stroke, is shown by the heavy line at the right hand upper corner. At full stroke it is hardly noticeable, at half stroke it opens at $\frac{1}{2}$″ before end of stroke, and at $\frac{1}{4}$ stroke it opens while Piston is 1″ from end of stroke.

Now to try a few experiments with the same valve. It is set line-and-line for full stroke and to cut-off at 12″, Chart D. This gives a 3/16″ lead at this point, valve opens to $\frac{1}{2}$″ when piston has travelled 1″ and to 9/16″ at 2″. Here it stays until the piston reaches 4″, then starts to close and cuts off at 12″. Exhaust does not open until 20″ or a little later than before with this cut-off ; is practically wide open at end of stroke ; begins to close at 8″ of return stroke, closing entirely at $19\frac{1}{2}$″ of return travel as against 19″ previously. Now setting the valve to have ⅜″ lead at full stroke, it has 9/16″ when hooked up to 12″ cut-off, Chart E. At 2″ of piston travel the valve is open 13/16″, remains at this figure for 1″ and commences to close, cutting off as before at 12″ piston travel. Exhaust opens earlier, $18\frac{1}{2}$″, and begins closing 1″ earlier or 9″ of return stroke, closing for compression at $18\frac{1}{2}$″ of return stroke, thereby increasing compression. Pre-admission is also very early, making compression rather high.

Going to the other extreme. Chart F, valve set $\frac{1}{4}$″ " blind " (or lap) at full stroke, is 1/16″ blind when hooked up. It opens, however, when piston has only moved $\frac{1}{4}$″, is open $\frac{1}{4}$″ when piston has moved 1″ and at 3″ is open ⅜″, stays there until 5″, and cuts off at 12″. Expansion continues up to 21″, when exhaust opens, and though it commences to close at 6″ of return stroke, compression does not begin until $20\frac{1}{2}$″.

Setting valve line-and-line again, put on $\frac{1}{4}$″ inside lap, Chart G, and compare this with Chart D (same setting). The steam opening will, of course, be the same, but the exhaust is affected by being held until $2\frac{1}{2}$″, beginning to close at 3″ of return stroke, and closing for compression at $17\frac{1}{2}$″, 2″ earlier than before. This, together with the pre-admission, makes a high compression, and is not desirable. Chart H, inside clearance has been applied to same valve, and as this is done more often than inside lap, it may be concluded it has been found more satisfactory. Steam line remains the same in H, but exhaust opens earlier, $18\frac{1}{4}$″, and begins to close later, 12″, final closure at $3\frac{1}{4}$″, compression consequently much lower than before. As one of the difficulties is getting rid of steam at high speeds, this should be an advantage. At shorter cut-off, the exhaust closes earlier (compare Charts B and C.) and inside clearance is, therefore, most needed for high speeds.

Chart 1 shows same valve as Chart G, except lap has been increased to $1\frac{1}{2}$″. The lead is 3/16″ with reversing lever set to cut-off at half stroke. When piston has travelled 2″ the port is open $\frac{3}{4}$″, and after 4″ is reached it gradually closes. Exhaust opens at $20\frac{1}{2}$″, being wide open $23\frac{1}{2}$″ and starting to close at 13″ of the return stroke. Compression begins at 19⅝″.

Chart J should be compared with Chart C, as the valves are the same except that the lap is increased.

Chart K shows the same cut-off and similar conditions except that the lap has been reduced to $\frac{1}{2}$″. This valve has only 1⅝″ travel and the port opens but 7/16″. Exhaust opens at a trifle past 19″, but does not open wide with, this proportion of valve and seat, the maximum opening being $\frac{3}{4}$″.

Chart M shows a valve with 5″ maximum travel, set for half stroke. It has only $\frac{3}{4}$″ lap and for this cut-off travels but $2\frac{1}{8}$″. The lead is $\frac{1}{8}$″, maximum port opening $\frac{3}{8}$″. Exhaust opens at 20″, opens to 1″ and begins closing at 7″ of return stroke. Compression begins with piston within 6″ of return stroke.

TO SET THE VALVES ON A TWO-CYLINDER ENGINE FITTED WITH STEPHENSON'S GEAR.

It is essential at the commencement of operations to be certain that the engine is at its correct working height.

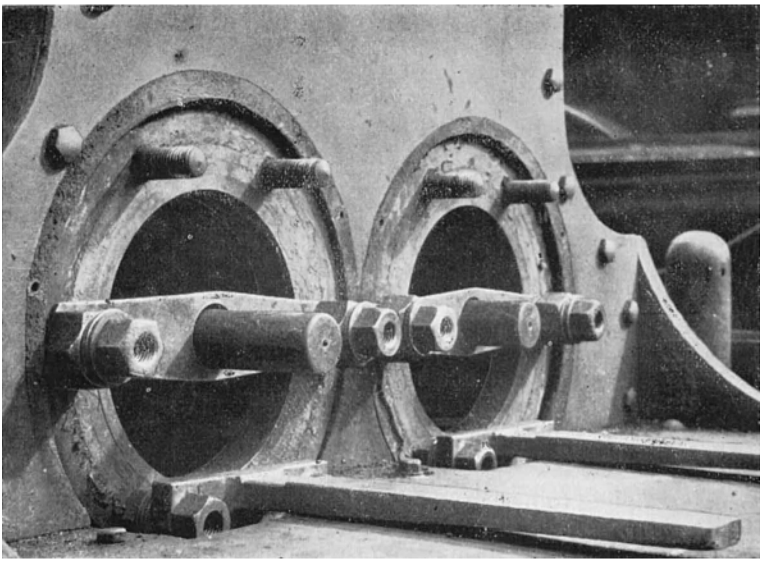

FIG. 2.

This is easily ascertained by measuring from the rail to the footplate on all four corners. The front valve covers are then removed and the valve spindles set central with the port by means of a bracket, which is affixed to the studs that hold the front valve cover. The holes in this bracket are large enough to allow a little movement, so that with the aid of a pair of inside callipers the valve spindle is soon in its correct position. To enable the various positions of the valve to be readily seen when the valve has a short spindle, a platform is arranged immediately under the bracket and is held firmly in position by the valve cover studs (Fig. 2). This platform should be made of some soft metal, so that marks made by a scriber can be easily filed out. It is most essential that this platform shall not move during the whole of the operations, and to check this occasionally, at a convenient point on the cylinder face make a small centre pop, and with trammel " A " in this pop, strike an arc on the platform. Where the valve has a long spindle this platform is unnecessary as all marks relating to the various positions can be scribed direct on to the valve spindle. So make a small pop in a convenient position on cylinder face so that with trammel " A " all positions of the valve will be obtained.

To Strike the Dead Centres.

Now having made these preliminary arrangements, the engine should be turned round : this can be done by hand or by machines. In the case in question the engine will be barred round by hand, the problem of machines will be dealt with later. The number of men required to turn an engine round naturally varies with the class of engine, but generally at least five men with bars will be required.

Commence moving engine forwards, and when the crosshead is within $\frac{3}{8}''$ to $\frac{1}{2}''$ of the " bump " mark—i.e. a mark scribed on the motion bar by the erector when the piston is hard against the cylinder cover in back and forward positions before the connecting rod is fitted—the engine is stopped and with a small U-trammel the position of the crosshead is scribed on the motion bar. This position of the engine has also to be marked on the driving wheel ; on some convenient point on the engine frame make a " pop " with a centre punch. With trammel " B " in the " pop, " strike an arc on the flange of the driving wheel ; now take a special scriber which fits round the tyre of the wheel and cut this line and where the lines intersect make a small " pop. "

Continuing to bar the engine round, the crosshead will travel to its extreme limit and commence the return stroke. Allow the line scribed by the U trammel on the motion bar to be passed, by at least $\frac{3}{4}''$, stop the engine and bar round in opposite direction. Place one leg of the U trammel in the centre " pop " on the crosshead, and when the other leg of this trammel coincides with the line previously scribed on the motion bar, stop the engine. The driving wheel of the engine is marked in the same way as previously described, so with trammel " B " in the " pop " on the frame strike an arc on the flange of the driving wheel and with special trammel cut this line and make a small " pop " where they meet. Now the middle point between these two " pops " should be the dead centre, so with a pair of dividers find this mid-point and mark it well, and with the ball of the hammer erase the two smaller ones. The other three centres are obtained in exactly the same way.

It may be noticed that the second of the two small " pops " on the driving wheel was obtained when engine was barred round in reverse, the reason is that any wear or " slogger " in the motion is then equalised.

As will be apparent, the driving wheel should be divided into four equal parts by the dead-centre "pops" and to check this, when the second centre is marked, the distance this is from the first one is measured by a trammel, and this distance checked on second to third, and third to fourth.

To Obtain Point of Exhaust and Cut-off.

(1). Internal admission.

Place quadrant in first notch in fore-gear and commence to move engine forward. The first mark on the brass platform will be point of exhaust, and this is obtained by carefully watching the valve, and when it is found that it is just possible to enter a ·002″ feeler between the valves and valve exhaust port, the engine is stopped ; place trammel, " A " on the end of valve spindle in suitable centre hole and scratch a line on brass platform. This line represents the exhaust point, and if the outside lap is marked on each side of this line it will represent the points of cut-off fore and back gear respectively.

(2). Outside admission.

The point of cut-off is obtained direct. As the valve is closing the port, allow a ·002″ feeler to enter between valve and port. Stop the engine and with trammel " A " on valve spindle scratch the brass platform ; this line represents the point of cut-off. If the outside lap is measured from the point of cut-off and a line scribed, the exhaust point will have been obtained, and if the outside lap is again measured off from the point of exhaust the cut-off for other end of valve will have been found. In the case of slide valves the " port marks, " as they are sometimes called, are scribed on to the valve spindle, and are obtained previous to valve setting by jarring the valve gently by hand until a ·002″ feeler can just enter between the valve edge and valve seat, and then with trammel kept for this particular engine, scribing the valve stem, and marking very carefully with a small centre punch. If the valve edge should be unequal top and bottom, so that a ·002″ feeler will go in, say, the top, and the bottom shows a 1/64″ open, equalise it. The erectors will then put the valve cover on and make the joint.

To Obtain Lead, Valve Opening, Valve Travel and Link Clearances.

Prepare the following table. Place gear lever in last notch back gear and commence to bar engine round backwards, after having first seen that an assistant is placed under the engine ready to take the centres. So when trammel " B " (as used previously in obtaining dead centres) fits into the " pop " on the frame and the " pop " on the driving wheel, the engine is stopped. (Should a centre be passed, do not bar the engine back to it, but go back some 8″ or 10″ and come up to it again). The engine is now at a dead centre, and a glance at the crosshead enables one to see easily at which centre. Suppose it to be the R.B. centre, so with trammel " A " in " pop " on valve spindle scribe a short line on the brass platform in front of the R.H. valve. The distance between this line and the respective cut-off line will be the lead, and it can be a negative or positive lead. Fig. 3 shows the difference between a negative or positive lead. Now enter this measurement in the table as the lead for the R.B. in reverse. Commence to move engine backwards, and

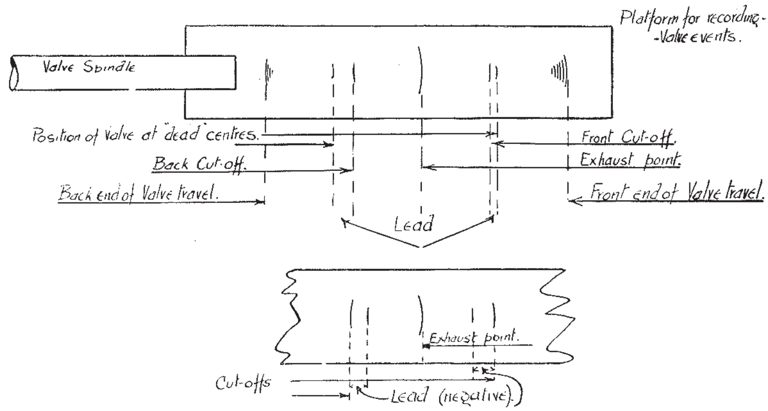

FIG. 3.

then measure the clearance between the link block and the top of the link, and enter the measurement in the table. Take trammel " A " and with point in " pop " on R.H. valve spindle keep faintly scratching the brass platform, and when it is seen that the valve is returning measure the distance between the bright patch and the cut-off mark. This will be the valve opening for the R.B. in reverse, enter it into the table. The engine will again be stopped when the next centre is reached, and the lead, link block clearance, and valve opening taken and entered into the table as described. The same procedure is taken with the two remaining centres. The engine is stopped after reading the fourth valve opening, and reversing lever placed in the last notch forward, and engine barred round forwards. The leads, valve openings and link block clearance are measured and entered into the table precisely as described before. The table when completed may look something like Fig. 4. Now suppose this engine should have equal leads, and in fore gear they are to be 3/16″ and in back gear $\frac{1}{8}$″, therefore the total lead in fore gear should be ⅜″ and

ENG. No.	WORKING HEIGHT.	Front. Back.			
	FORE GEAR.		BACK GEAR.		
	lead.	Opening.	lead.		Opening.
R. F.	16/64 B″ D 1/16 F″	1 1/16 B″	14/64 B″	D 1/16 F″	1 1/16 B″
R. B.	7/64″	1 9/16″	4/64 FF″		1 3/8 FF″
L. F.	14/64″ D 1/16 F″	1 1/16 F″	10/64 F″	D 1/32 F″	1 1/16 F″
L. B.	5/64″	1 5/8 F″	6/64 B″		1 1/16″
R. F.	11/64″	1 1/2″	9/64 F″		1 1/16″
R B	11/64″	1 9/16″	9/64 B″		1 5/16″
L. F.	10/64 B″	1 1/2″	8/64 F″		1 1/16″
L. B.	10/64 B″	1 5/8″	8/64 B″		1 3/8″
Cylinder Clearances.			Link Clearances.		
R F 1/4 F″	L. F. 5/16″		R Top. 1/2 B″	L Top. 1/16 F″	
R B. 1/4″	L B. 1/4 B″		R Bottom. 7/16″	L Bottom. 1/2″	

Take "A" portion of table.

Total lead should be 3/8″ in Fore & 1/4″ in Back Gear.

R. HAND { F 16/64 F″ ; B 7/64 FF }   { F. 13/64 B″ ; B 3/64 FF″ }

Take 4/64 F″ off F & add to B.   Take 4/64 F″ off F & add to B.

L HAND { F 16/64 FF″ ; B 7/64 FF″ }   { F 10/64 F″ ; B 6/64 B″ }

Take 4/64 F″ off F & add to B.   Take 2/64 F″ off F & add to B.

FIG. 4.

total lead in back gear should be $\frac{1}{4}$″. Looking at the table the total lead in fore gear, right side, is $16/64^{B}{}''+7/64''=23/64^{B}{}''$, so there is 1/64″ lead short. Again in fore gear, left side, there is 14/64″+5/64″ = 19/64″, so here there is 5/64″ lead short. In back gear, right side, total lead is 14/64B″+4/64FF″ = 18/64″, so here there is 2/64″ lead more than required. Again, back gear, left side, total lead is 10/64F″ +6/64B″ = 16/64″, which is correct.

The inequalities are caused by the eccentric sheaves, and as they are keyed and also made in pairs, the slight difference is ignored. It will have been noticed that all lead measurements have been read in 1/64's of an inch.

Now take the lead in fore gear :—

Right side { R.F. 16/64B″
R.B. 7/64″

The rule is add or subtract an amount to bring the total lead to the correct amount, ⅜″ or 24/64″, by adding or subtracting this amount equally to both R.F. and R.B. In this case it requires 1/64F″ added, and to add this equally it would require 1/128F″ on the R.F. and R.B. In this case (valve setters reckon 1/64″ = FFFF) add FF to R.F. and R.B. :—

R.F. 16/64F″
E.B. 7/64FF″ =23/64FFF″

to equalise the leads 4/64F″ off R.F. and added to R.B. :—

R.F. 12/64″
E.B. 11/64FFF″

So the eccentric rod governing the right fore gear is to be lengthened 4/64F″ : since the valve has inside admission and direct action, so drawing or lengthening the eccentric rod will push the valve forward, thereby closing the front port and opening the back one.

Take the fore gear, left side :—

L.F. 14/64″ } add or subtract an amount to bring the total
L.B. 5/64″ } lead to 24/64″ etc., as above.

Here 14/64″+5/64″ = 19/64″, so add 5/64″, i.e. 2/64FF″, to the L.F. and L.B. :—

L.F. 16/64FF″ } =24/64″ the correct lead.
L.B. 7/64FF″ }

To equalise the leads take 4/64FF″ from L.F. and add it to L.B. :—

L.F. 12/64″
L.B. 12/64″

Therefore lengthen this eccentric rod 4/64FF″.

Do exactly the same with back gear, right side :—

R.F. 14/64B″ } in back gear the total leads are 16/64″, so take
R.B. 4/64FF″ } 2/64″ away, i.e. 1/64″ from R.F. and R.B.

R.F. 14/64B″ }
R.B. 3/64FF″ } =16/64″ correct lead.

To equalise the leads, take 4/64F″ from R.F. and add it to R.B. :—

R.F 8/64F″
R.B. 7/64FFF″ so lengthen eccentric rod 4/64F″.

In the final rod, back gear, left side :—

L.F. 10/64F″ }
L.B. 6/64B″ } =16/64″ the correct lead.

To equalise the leads take 2/64F″ from L.F. and add to L.B. :—

L.F. 8/64″
L.B. 8/64″ lengthen rod 2/64″.

On turning this engine over again the leads worked out as shown in the second part of the table in Fig. 4.

With regard to long reversing rod changes, if a rod is lengthened the full gear forward travels would be lengthened, and the back gear travels shortened, while the lead in full forward gear would be decreased at each end, and increased each end in full back gear. Shortening a long reversing rod causes an opposite effect.

Cylinder clearances present no difficulty ; in the case of a front clearance being too small, the required amount can be machined off the cover. If the back clearance is insufficient, the connecting rod could be adjusted. The eccentric rods are now marked for alteration and if no adjustment is provided for lengthening or shortening them, they are sent to the Smith's Shop. Assuming the rods have been altered and replaced, the lead marks on the brass platform are removed by rubbing with emery cloth (only the lead marks). The engine is then barred round again, and the centres, leads, valve openings, etc., are taken exactly as previously described both in fore and back gears and entered into second part of table. In addition the piston clearances are also taken. They are obtained by placing a small square against the crosshead when the piston is on its dead centre and scribing a line on the motion bar. The distance between this line and the "bump" mark (as previously described) is the clearance the piston has from the cylinder cover when it is in the position of its extreme travel. When the four readings in back and fore gear have been taken and the valve setter is satisfied that the valves are set correctly a test can be taken of the actual distance of the stroke that the cut-off and exhaust point take place, at full gear and at 25%, also the lead at 25%. This is usually taken in fore gear and the right hand side only.

First prepare a table. Pull engine back until there is sufficient room to give one complete turn forwards and allow R.H. back centre to be passed about $\frac{1}{2}''$ on motion bar. This is done so that by the time the R.H. back centre is reached all " slogger " due to wear, etc., in all parts of the motion will be taken up. Place reversing lever in 25% fore gear and move engine forwards. Stop on the dead centre, i.e. R.H. back centre. Mark the lead on the brass platform, measure and enter into table.

Move engine forwards and mark extreme travel of valve, measure from the cut-off line, enter into table. Continue to move engine forwards and the valve will commence to return ; hold trammel " A " on valve spindle and when the cut-off line is reached stop the engine. Now measure the distance the R.H. crosshead has travelled from the R.H, back centre, and enter in table. Move engine forwards, again holding trammel " A " on centre hole on valve spindle and when the point of exhaust is reached stop the engine. Again measure the distance the R.H. crosshead has moved from back centre and enter into table. If the valve has no exhaust lap, the point of exhaust is also the point of compression for the other head of valve.

The lead at 25% in fore gear has been taken and also the cut-off and exhaust points have been measured. Now if the reversing lever is placed in last notch fore gear, the valves will move sufficiently to allow the taking of the cut-off and exhaust points in full fore gear. So place reverse lever in the last notch forward and move engine forwards, holding, trammel " A " on valve spindle. When the point of cut-off is reached, stop the engine and measure distance the R.H. crosshead has travelled from its back centre. Enter this measurement into the table. Move the engine forwards again, and catch the exhaust point with the trammel "A" on valve spindle. Stop the engine and again measure the distance traversed by the crosshead from its back centre. Now the forward stroke of the engine in fore gear has been completed and readings in full and 25% fore gear, of the lead, cut-off and exhaust point have been obtained. By continuing to move the engine forwards the reading for the backward stroke of the engine in fore gear can be taken and the cycle completed.

Now place reversing lever on the 25% mark in fore gear, and catch the R.H. front centre as it comes round. With trammel " A " on valve spindle, mark the brass platform and measure the lead and enter into table. Move the engine forwards and with trammel " A " on valve spindle mark extreme travel of valve, measure from cut-off, enter into table. Still holding the trammel on valve spindle stop the engine when the cut-off is reached, measure distance the R.H. crosshead has travelled from the front dead centre and enter into table. Continue to bar the engine round and when point of exhaust is reached, stop, measure the distance the R.H. crosshead has moved from its front dead centre, and enter into table. Now move the reversing lever into the last notch fore gear, when the valves will now move to allow the cut-off and exhaust points to be taken. So continue to bar engine forwards, and with the trammel on the end of valve spindle, catch the cut-off and exhaust points, measuring each time the distance the R.H. crosshead has travelled from its front dead centre, and record accordingly.

A complete record of the valve functions for one cycle of the engine in fore gear has now been taken, and if it is satisfactory the setting of the valve will be completed. If, however, the cut-offs should be more than $\frac{3}{4}''$ different, it would be better to rectify the cut-offs at the expense of the lead, so suppose the front cut-off is $22''$ and the back $23\frac{1}{2}''$, the difference is $1\frac{1}{2}''$, take half of this $\frac{3}{4}''$ and add it to the shorter cut-off, $22''$, move engine round to pick up the front cut-off and continue until the cross-head has travelled $22\frac{3}{4}''$ from its dead centre, then with trammel " A " mark brass platform, and the difference between this line and the front cut-off line is the amount the eccentric rod should be altered.

SETTING VALVES ON TWO-CYLINDER ENGINE FITTED WITH WALSCHAERTS GEAR.

This is a common gear on locomotives, and was invented by Walschaert in 1844. It differs from Stephenson's gear in that it only requires one eccentric, or its equivalent, to each cylinder and the lead is constant. The eccentric is secured to the driving axle either directly, or by a return crank from one of the crank pins. The link is actuated by the, eccentric rod, which is usually attached to a projection extending below it, and the block is coupled to one end of the radius rod. Raising or lowering this rod by means of the reversing shaft moves the block from one end of the link to the other. This reverses the movement of the valve with relation to that of the eccentric, so in fore-gear, the motion is direct and in back gear, indirect, or vice versa. The end of the radius rod opposite the link is attached to a combining lever, the use of which is to give the required amount of lead to the valve. The lower end of the combining lever is connected to and travels with the crosshead, while to the upper end are secured both the radius rod and valve rod—one being placed a short distance from the other. With inside admission the radius rod is above the valve rod, and with outside admission the rod is below the valve rod.

Eng. No.		Working Height.		Front. Back.			
		Fore Gear.			Back Gear.		
		lead.		Opening.	lead.		Opening.
A	R.F.	5/64"		1 3/4"	17/64"	D 10/64"	2 1/4"
	R.B.	15/64"	D 3/16"	1 7/8"	7/64"		1 3/4"
	L.F.	13/64"	(4/64" on)	2"	C.O.	J 13/64"	1 7/8"
	L.B.	8/64"	D 3/16"	1 3/8"	21/64"		1 7/8"
	R.F.	10/64"		1 15/16 B"	12/64"		2 1/16 F"
	R.B.	10/64"		1 7/8 F"	12/64"		1 3/4 B"
	L.F.	10/64 FF"		2 1/16"	10/64 FF"		1 15/16"
	L.B.	10/64 FF"		1 1/2"	10/64 FF"		1 5/8"

Cylinder Clearances				Link Clearances			
R.F.	5/16"	L.F.	1/4"	R Top	7/16"	L Top	1/2"
R.B.	3/16 F"	L.B.	1/4 B"	R Bottom	1/2"	L Bottom.	1/2"

Take "A" portion of table. lead F & B to be 5/16".

R
5/64" → 15/64"
15/64" → 5/64" draw Rod 5/64" ×

L
12/64 FF" FF" (negative)
7/64 FF" 20/64 FF"
draw valve forward 1/16.

16/64 FF" → 3/64 FF"
3/64 FF" → 16/64 FF" Shorten Rod 6/64 FF"

× see text

Fig. 5.

To set the valves proceed exactly as outlined for the Stephenson's gear. Obtain the dead centres, turn the engine round in fore and back gears, measure lead, valve openings, link clearances, piston clearances, precisely as previously described, and enter all in a similar table. Suppose that to have been done and the table is as in Fig. 5, and the motion is direct in fore gear, indirect in back gear and inside admission valves. Lead required 5/16″. As in Stephenson's gear, the rule is, bring the total lead to that required by adding or subtracting equally on the front and back in fore and in back gears.

Take the R.H. side in fore gear 5/64″+15/64″ = 20/64″ the correct lead, and in back gear 17/64″ +7/64″ = 24/64″ being 4/64″ too much, so take 2/64″ off each side :—

15/64″+5/64″ = correct lead of 20/64″.

In Walschaert's gear it is necessary, to enable one to determine correctly the required rod alterations, for the leads to be equal when crossed over:—

i.e. the R.F. lead in fore gear equal to the R.B. in back gear and the R.B. in fore gear equal to the R.F. in back gear, as shown by arrows in Fig. 5.

In the case in question they happen to be so, therefore the rod alteration can be worked out. The eccentric rod will require lengthening 5/64″. Take the L.H. side, bringing the leads to the correct figure of 20/64″, they are :—

12/64FF″	FF (negative)″
7/64FF″	20/64FF″

To make the leads equal when crossed over, draw valve forward 1/16″ (calculation only). This will increase the lead in R.F. fore gear by 4/64″, and decrease the R.B. in fore gear by 4/64″, also in back gear, the R.F. is increased 4/64″ and the R.B. decreased 4/64″, so :—

16/64FF″	3/64FF″
3/64FF″	16/64FF″ as in Fig. 5.

Now it is seen that the rod alteration should be shorten 6/64FF″. If there is a nut adjustment on the valve spindle the L.H. valve requires drawing 4/64″, shown adjacent to the L.F. in fore gear, in Fig. 5. If there is no nut adjustment the valve rod is drawn 4/64″.

Although the eccentric rods show they require an alteration of, lengthening 5/64″ and shortening 6/64FF″ respectively, in the table, this is not the actual or final alteration. Just consider the link and link foot in Fig. 6. The link swings about its fulcrum, and the link block is at a different radius from the link fulcrum to that of the link foot (where the eccentric rod is attached). The proportion is 1—2, so the eccentric rod alteration will have to be doubled. (This proportion is fixed by the designers, so it will have to be determined for each class.of engine). So the actual and final rod alteration for this engine will be, lengthen 10/64″, and the other rod shorten 13/64″.

There are two other alterations, and they are the R. and L. intermediate reversing rods. They may have to be altered to comply with the designer's requirements as to valve openings. In the table they are shown at R.B. and L.B. in fore gear as D. 3/16″. When working out any adjustment on these rods be sure of the proportions of the rocker.

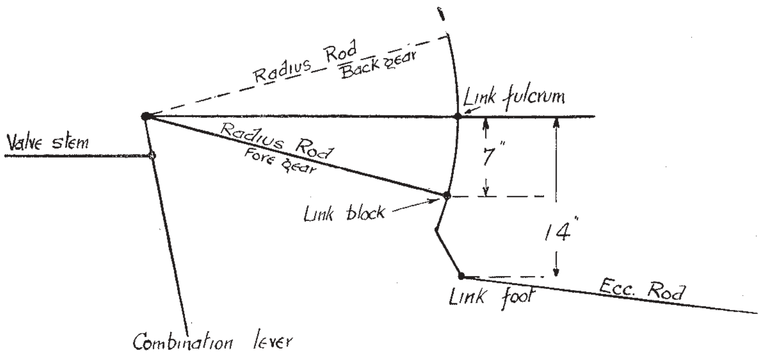

FIG. 6.

SETTING VALVES ON FOUR-CYLINDER ENGINES, INSIDE VALVES, DRIVEN BY WALSCHAERT GEAR, AND OUTSIDE CONNECTED BY SUITABLE BEAMS OR ROCKERS TO THE INSIDE.

The Great Western four-cylinder engines are of this type, and the outside and inside engines for the purpose of valve setting are considered separately. The procedure is exactly similar to that of Walschaert's gear on two-cylinder engines. The inside engine readings are taken on one table and the outside on another.

The valve events are obtained precisely the same as in other engines previously described, and any alterations required are worked out for each engine independently. When they are compared, each engine should show the same amount of alteration as regards eccentric rod, intermediate reversing rod or long reversing rod. A point to be borne in mind is, that the outside valves have a different motion to the inside ones, so if the inside valves are direct motion in fore gear and indirect in back gear, the outside valves would be indirect in fore gear and direct in back gear. This makes no difference to the taking of valve events, but has to be remembered when calculating alterations, should they be necessary. So it is obvious that the inside engine controls the outside, and any alteration made to the motion of the inside has its corresponding effect on the outside engine.

Each valve spindle is adjustable for length by means of a rack nut. If the thread on the valve spindle is 16 to the inch and the nut has 16 racks, it is apparent that eight castellations from the locking device are equal to half a turn or 1/32″ variation of the valve spindle, while four castellations from the locking device is a variation of 1/64″.

Two valve setters are employed when setting the valves of a four-cylinder engine, one for the inside engine, the other recording the readings for the outside engine. The valves being operated by Walschaert's gear, follow the instructions for setting valves on two-cylinder engines fitted with Walschaert's gear.

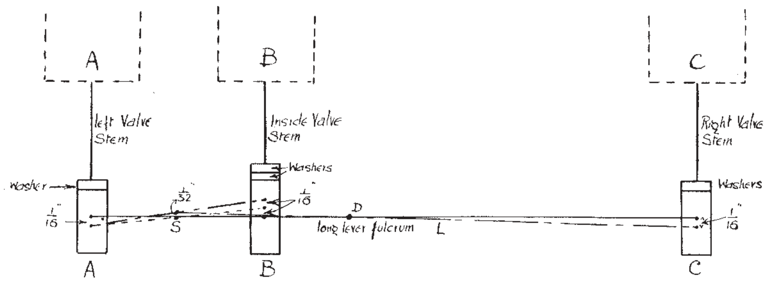

Fig. 7.

VALVE SETTING THREE-CYLINDER ENGINES, WITH "WALSCHAERT'S" OUTSIDE AND "GRESLEY" INSIDE LEVER GEAR.

The outside and inside valve stems carry extensions in the front, each extension has the necessary bearing support, and a short link connects the valve stem extension with its respective lever. Fig. 7 shows a diagram of the three valve chests, with levers connecting the three, tails of the valve stems. The R.H. valve is coupled to one end of a long two-to-one-lever, with its fulcrum at D ; on the other end of the same lever is an equal-armed floating lever, each end of which is coupled to a valve spindle. The two outside valves are driven and it is quite clear that the motion of the middle valve must be compounded of the other two, and a close analysis shows that it is exactly what is required.

A B and C are the valve stem extensions and S and L are the short and long levers. If a 1/16″ washer is placed in valve stem extension A, the floating lever S being pivoted at O would move the valve B back 1/16″, and if a 1/16″ washer were placed in valve stem extension C the point O would be levered back 1/32″ (lever L being 2—1), now the valve stem A being stationary and acting as a pivot the valve B is levered back 1/16″. So by the changes of washers at valve stem extensions A and C, the inside valve is levered back an amount equal to the sum of the washer thicknesses. Therefore, if before the suggested changes, the inside valve was correctly set, to rectify the valve events now the washer thickness at B has to be reduced ⅛″.

To set the valve, first set the outside engine completely and make all necessary alterations before commencing the inside valve adjustments. This is simply a two-cylinder Walschaert's gear engine and has already been described.

Port marks. On an engine where inside admission valves are used an allowance of 1/32″ for the outside and 3/64″ for the middle valve is made. The outside allowance is marked ahead and the middle valve allowance behind the centre of the port marks. For an outside admission valve no allowance is made for the outside valves, but the middle valve has an allowance of 5/64″ marked behind the centre of the port marks.

Now suppose the outside engine to be finished, place reverse lever in 33% fore gear, and mark the front and back inside valve travel on the valve stem, or bracket if used. Find the centre of the valve travel, and if it coincides with the centre of the port marks the middle valve events may be considered correct. If the centre of the valve travel is incorrect the washer thickness at B is altered accordingly.

VALVE SETTING AN ENGINE FITTED WITH CAPROTTI VALVE GEAR (Fig. 8).

(Through the courtesy of William Beardmore and Co., Ltd.).

Fig. 1 is a section through the cylinder showing the admission valves, while Fig. 2 is a section showing the exhaust valves. It must be understood that each cylinder is equipped with four poppet valves, A, working in the vertical plane. There are two valves at each end of the cylinder, one operating the admission and the other the exhaust. The cams for controlling the valve movements are mounted so that they may be turned by a revolving shaft driven by any suitable means from one of the coupled axles ; the angular velocity of this shaft must be (as in any form of valve gear of this particular type) exactly the same as that of the driving axle. The Caprotti system employs three cams for operating the four valves for each cylinder, two cams, B, B1, control the steam valves, and one, C, the exhaust. The plan view of the operating arrangement is shown by Fig. 4. It will be observed that a crankshaft, D, is employed, and this, by means of the links, E, is coupled to the sleeves, F, which are very similar to the familiar eccentric straps. These embrace cylindrical pieces, G, G1, also shown separately in Fig. 3, cut to conform to a quick-pitch screw, H, which forms part of the revolving shaft, J. The two steam cams are located next to the crankshaft, D, whilst the exhaust cam is shown on the outer end remote from the crankshaft. The cams are loosely fitted on the revolving shaft ; they

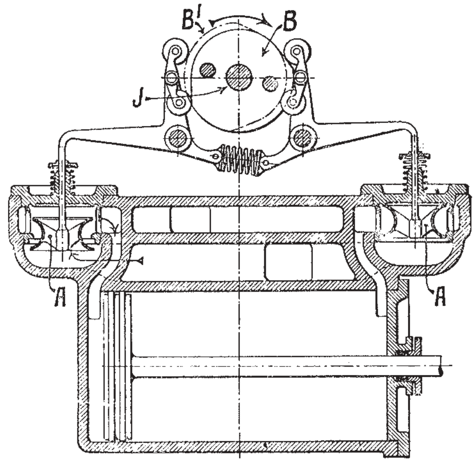

Fig. 1.

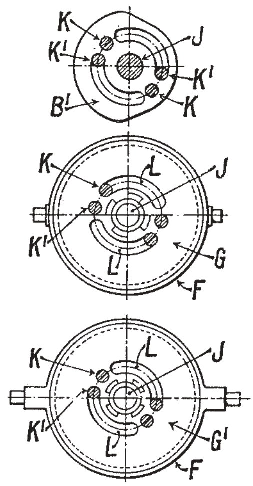

Fig. 3.

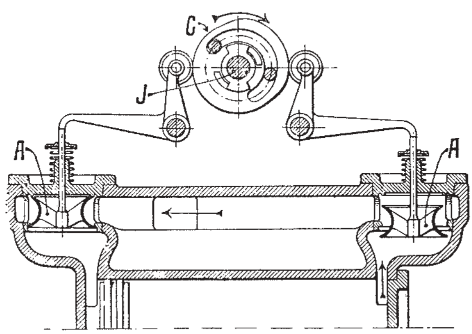

Fig. 2.

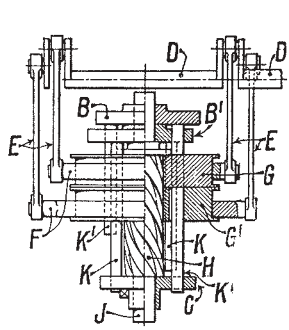

Fig. 4.

Fig. 8.

are, however, given a rotary motion by means of cylindrical bars, K, K, Kl, Kl, which are driven by the cylindrical pieces engaging on the quick-pitch screw. Slots, L, L, Fig. 3, cut as shown in the cylindrical pieces, allow the direction of motion and the functions of the cams to be reversed, the cylindrical pieces again taking over control when they have been turned through a sufficient angle. Referring to Fig. 1, it will be noticed that the valves are actuated by bell cranks, the ends next the cams being fitted with equal arm levers carrying rollers bearing directly on the two steam cams. When running in the direction of the arrow, the cam shown by the continuous line is acting as the admission earn for the valve on the left, which, it will be noticed, has been opened, whilst the cam, shown by means of chain-dots, is acting as the cut-off cam. When it is desired to reverse the engine, moving the crankshaft by means of the links has the effect of reversing the functions of the two steam cams. The position of the exhaust earn relative to the valve operating levers, however, is not altered in so far as the time of the opening and closing of the valves is concerned until the reversing gear is in mid-position. Therefore, the points of release and compression remain the same whatever degree of cut-off is employed. Fig. 5 shows how the rotating shaft carrying the cams may be operated. P is a flexible coupling allowing for the rise and fall of the driving axle.

The valve events and steam functions inside the cylinders are entirely controlled by a system of rotating cams which are timed, relatively to the engine crank so as to give the designed amount of lead to steam admission, etc. In order to effect this relative timing, an index on the end of the camshaft is set to zero. The engine crank corresponding to that particular camshaft is then set at its inner dead centre, the camshaft being meshed into a system of bevel gear actuated from the driving axle. Thereafter the valve tappet clearances are set by rotating the gear to the "valve closed" position for each cam, in turn and then adjusting the clearance at the corresponding valve tappets to a minimum.

The gear is now in running condition and any further attention is solely confined to a periodical inspection of the tappet clearances which may require adjustment due to service wear.

It should be understood that the cams mounted on one camshaft are so set relative to one another, that after tappet clearance and proper registration of index to crank are made the valve events—lead, cut-off, compression, release—are phased automatically.

MACHINES FOR SETTING VALVES ON LOCOMOTIVES.

Previous to the air motor method of turning the driving wheels of an engine, a man sat in the pit and turned the wheels by means of a ratchet. This machine was called a "jigger."

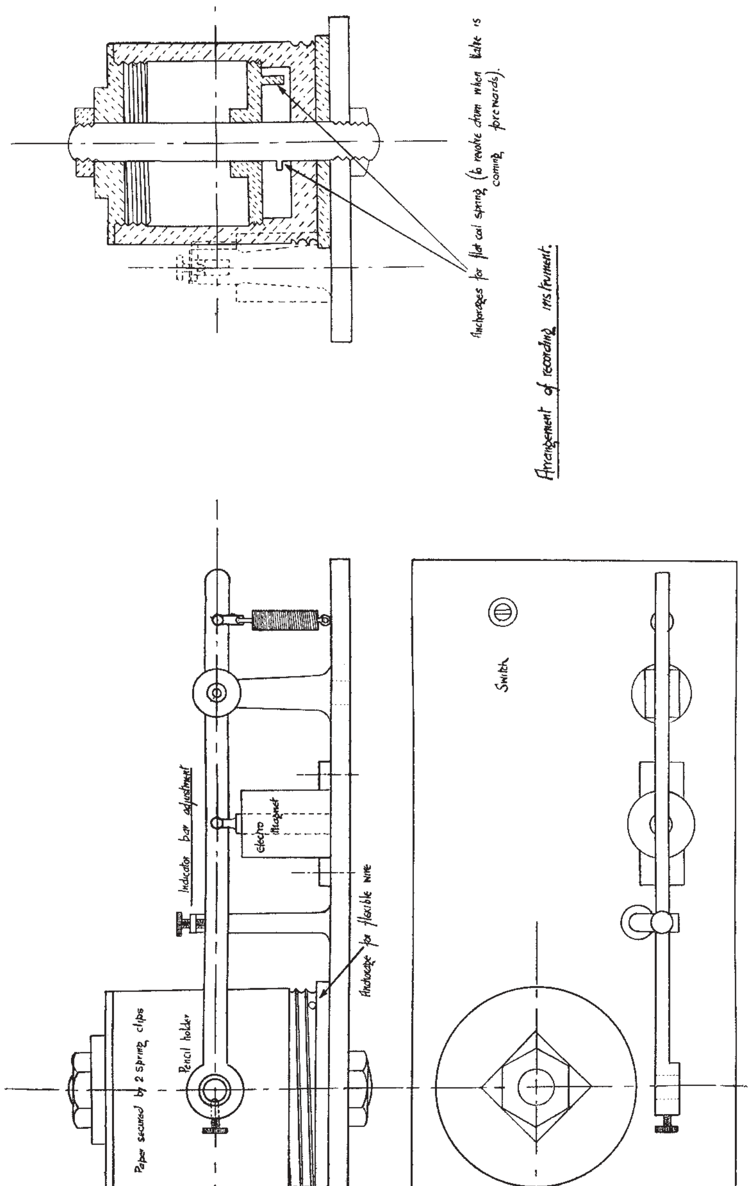
Anchorages for flat coil spring (to revolve drum when valve is coming forewards).
Arrangement of recording instrument.
Indicator bar adjustment
electro magnet
Anchorage for flexible wire
Pencil holder
Paper secured by 2 spring clips
Switch

FIG. 9.

Another development of the same principle (employed abroad) is for the turning shaft to project each side of the engine terminating in ratchets ; thus men can stand each side of the engine and work the ratchets.

Heavy American engines have been coupled to a live engine and moved slowly, arrangements having been made before actual valve setting to get the port marks, valve bump mark, and piston bump mark, and the main and auxiliary reversing rods adjusted.

The following is the Author's suggestion for a valve setting machine, which should give an actual record of valve events, similar to that of indicator diagrams. It consists of two principle parts, one shown in Fig. 9 is a recording drum, revolved by suitable means from the valve stem. Tangential to the drum is a bar holding a marking device similar to that of a barograph ; this bar is controlled magnetically, thus marking a vertical line on the drum when circuit is completed. One of the contacts for completing the circuits is mounted on the motion or slide bars of the locomotive, and the other one on the piston crosshead. That on the motion bar is insulated and connected to the recording instrument, while that on the crosshead is not insulated, merely a form of strip contact suitably placed, so that when the crosshead is within about an inch of the end of its stroke, contact is made, and the paper on the drum is marked by the bar marking a vertical line ; the bar is held down until the crosshead reaches the exact spot on its return stroke where contact was made, then the circuit is broken by the contacts coming apart, and the recording bar flies back to its normal position, marking another vertical line on the drum. The mid point between these two vertical lines is the dead centre.

The other part of the apparatus is a device to obtain the point of exhaust (for inside admission engines), or point of cut-off for outside admission, as outlined in figure. The valve when it reaches the point of exhaust or cut-off strikes a rod which in turn presses a contact, and the recording bar dips, but returns immediately to its normal position, through the plunger forcing contacts apart.

To take a record of valve events, the recording machine is mounted in front of the valve spindles on the footplate in such a way that when the valve is right forward there is still tension on the spring in the cylinder. The paper is fixed to the drum, contacts are mounted on the slide or motion bars, and the strip contacts on the crossheads. The arrangement for obtaining point of exhaust is fitted to the cylinder face as shown in Fig. 10 and connection is made to accumulator or electric mains, and the current switched on. (It should have been mentioned that the valve spindle is held central by the brackets as in other methods of valve setting, the reversing lever placed in full fore gear).

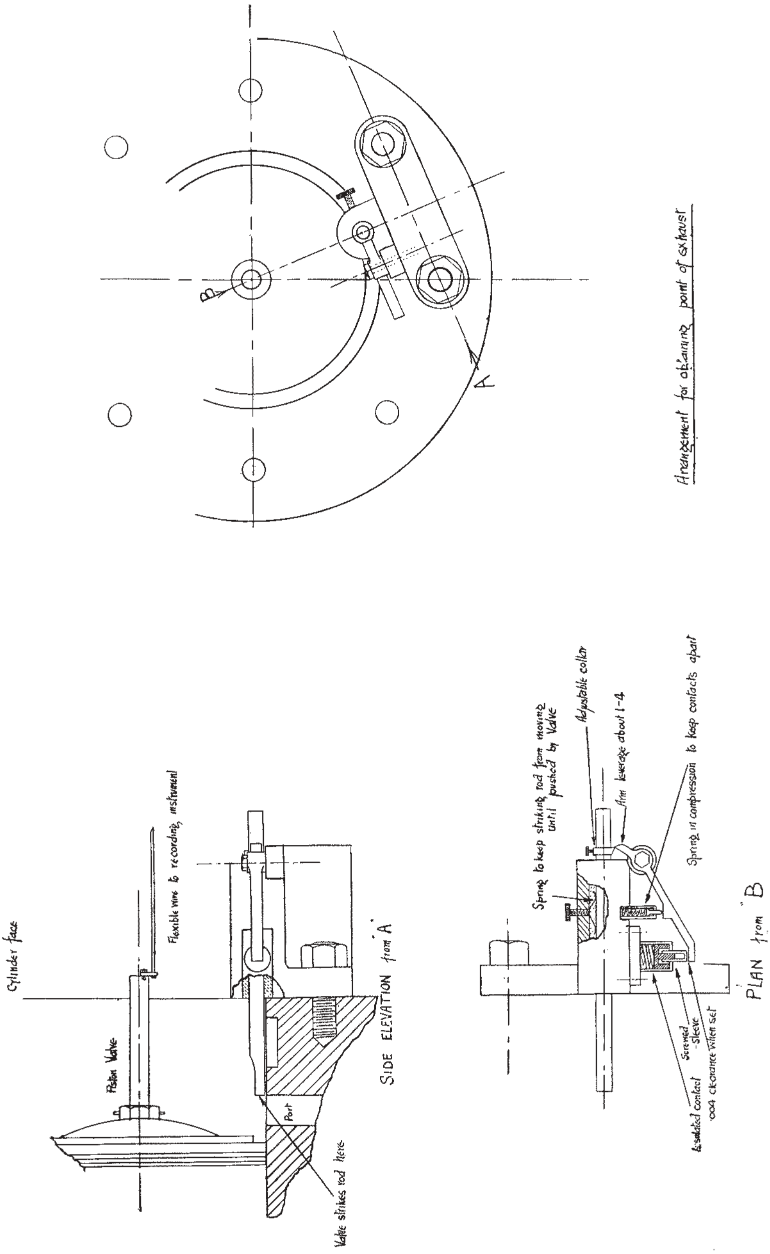
Arrangement for obtaining point of exhaust
A
B
Cylinder face
Flexible wire to recording instrument
Piston Valve
Port
Valve strikes rod here
SIDE ELEVATION from 'A'
Spring to keep striking rod from moving until pushed by Valve
Adjustable collar
Arm leverage about 1-4
Spring in compression to keep contacts apart
Insulated contact
Screwed sleeve
·004 clearance when set
PLAN from 'B'

FIG. 10.

The engine is now pulled forward one complete turn by the traversing table, the paper on the drums moved upwards to enable a second reading (that of the backward gear) to be taken on the same paper. Place reversing lever in full back gear and pull engine backwards one complete turn. Switch off, remove paper from the drums and find the dead centres and leads as shown in Fig. 11. Having found the leads, valve openings, cut-offs, point of exhaust and valve travel, work out the alterations required as before. The paper when removed from the drum could be filed for reference.

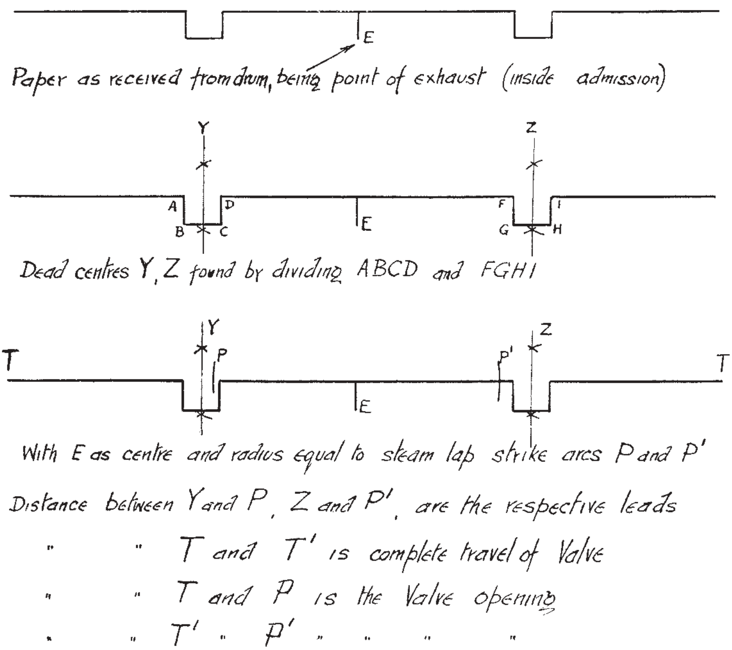

FIG. 11.

In conclusion, the Author gratefully acknowledges the excellent help and suggestions given him by Mr. W. Wheel, who placed his extensive experience of valve setting at the Author's disposal.