The BAKER LOCOMOTIVE VALVE GEAR

THE PILLIOD COMPANY

SWANTON, OHIO

Vol. 3 Nov., 1946

The Baker Locomotive Valve Gear

MANUFACTURED BY

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THE BAKER LOCOMOTIVE VALVE GEAR

The first patent was granted Mr. Abner D. Baker on March 3, 1903 for use on a traction engine. This valve gear was developed for use on a locomotive and its first application was on the Toledo, St. Louis & Western Railroad in 1908, the valve gear then being known as the Baker-Pilliod. It passed through a period of experiment and was discontinued in 1910, being replaced by the present Baker Locomotive Valve Gear, patent covering was granted on November 4, 1911. Since that time several additional patents have been secured on improvements, but the principle of operation has remained the same. This gear is also protected by patents in all of the important foreign countries.

The Baker Valve Gear is now in use on 15,000 locomotives and has been adopted as a standard by a continually increasing number of railroads. It is made in three different types—Standard, Long Travel and Long Lap. The Standard Gear is used for valve travels up to 7½″ and the other two types for travels between 7½″ and 9″.

Within the past few years there has been a remarkable advancement in locomotive construction in order to secure greater horse power, and a reduction in transportation cost. The Pilliod Company, in order to keep abreast of the times, developed what is known as the Baker Long Lap Locomotive Valve Gear. This gear will deliver to the valve a travel of 9″ which permits the use of longer steam lap. The use of this longer steam lap produces better valve events by increasing the port and exhaust opening and decreasing pre-admission with a corresponding reduction in compression.

There is a marked improvement in starting and maintaining higher speeds, with less fuel and water, over locomotives equipped with valve gears with shorter travel and less steam laps, as the port openings are greater and even in the short cut-off indicator cards do not show signs of wire drawing of steam.

Further, due to the increase in steam lap, which automatically produces larger exhaust openings, less exhaust clearance is required which gives a longer expansion. From a comparison between this gear and other gears with shorter travel, it was found there is an increase up to 30% in the port openings, and an increase up to 50% in exhaust opening, with a corresponding decrease of 40% in preadmission at 25% cut-off, which results in operating efficiency and steam economy.

DESCRIPTION

The Baker Valve Gear is an outside gear taking its motion from an eccentric crank attached to the main crank pin and from the main crosshead. It consists of an eccentric crank, eccentric rod, valve gear frame (which contains the reverse yoke, radius bars, bell crank and gear connecting rod) valve rod, combination lever and union link, together with the customary reversing arrangement of reach rods, reverse shaft, reverse lever, etc.

The reverse yoke is pivoted in the gear frame having the upper end attached to the gear reach rod. In the reverse yoke are pivoted the radius bars, to the lower ends of which the gear connecting rod is attached. This gear connecting rod extends downward, connecting with the eccentric rod, and upward, connecting with the bell crank which is pivoted in the gear frame. The motion derived from the eccentric crank is carried through the valve gear to the valve rod. It is here combined with the motion of the combination lever (lap and lead movement) and transmitted to the valve by means of the valve stem.

The principal parts of the Baker Gear, which are the gear frame and contained parts, do not depend upon the gear location for their shape. A standard design can be rigidly adhered to, using the same parts on several different classes of locomotives.

Figure 1

Figure 1 illustrates a Reuleaux diagram which has been adopted as standard by The Pilliod Company for calculating lap, lead, valve travel and maximum percentage of cut-off when any three conditions are given. When lap, lead and valve travel are given, the percent of maximum cut-off is determined as follows: With O as a center, the circle AB is drawn with a radius equal to one-half of the valve travel. The distance OE required lap, and AD required lead. With A as center, draw a semi-circle AD opposite OE. Draw a line DC tangent to the circle OE and semi-circle AD. From C draw a line CF perpen-

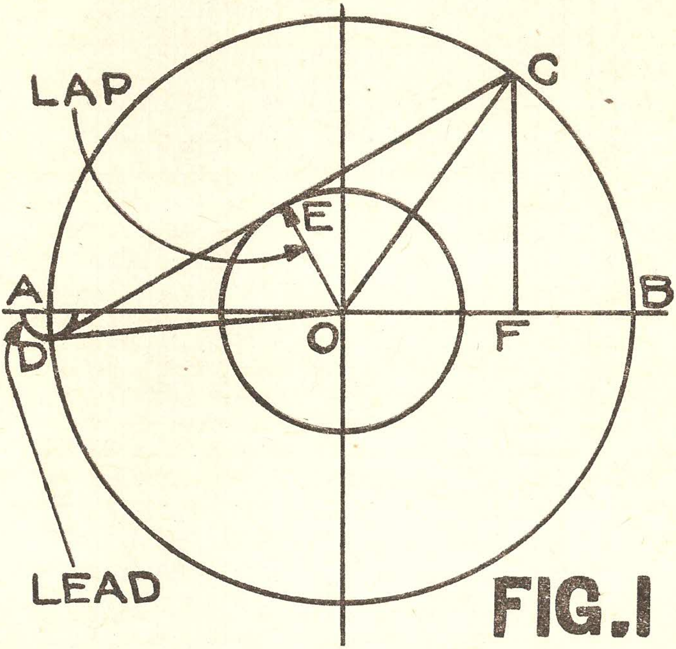

FIG. 1

dicular to AB. Then, the distance AF is the same percent of the distance AB, as the percent of cut-off will be to the stroke of the piston.

OC will be the cut-off position of the crank.

OD will be the position of crank when the valve starts to open or the point of pre-admission.

Figure 2

Figure 2 illustrates cut-off percentages obtained in full gear with valve travel from 6″ to 9″ with any given lap and lead. These percentages are taken from diagram shown in Figure 1.

LAP, LEAD AND VALVE TRAVEL GIVING PERCENT OF FULL GEAR CUT-OFF

Lead 1/8"

Valve Travel \ Lap	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"
6"	87.5	84.4	80.9	77.1	73.2	68.7	63.8	58.4	53
6 1/8"	88	84.9	81.6	77.8	73.9	69.8	65.2	59.8	54.8
6 1/4"	88.5	85.3	82.2	78.9	75.2	70.8	66.4	61.6	55.9
6 3/8"	88.8	86.1	83.3	79.4	76.5	72	67.8	63.2	58.7
6 1/2"	89.4	86.7	83.5	80	76.9	73.2	68.6	64	59.8
6 5/8"	89.8	87.2	84.3	81.2	77.8	74	70.2	66.3	61.3
6 3/4"	90.2	87.7	85	81.8	78.8	75	71.5	67.3	63
6 7/8"	90.5	88.1	85.3	82.5	79.5	75.9	72.3	68.4	64
7"	91	88.4	85.9	83	79.9	76.8	73.2	69.4	65.4
7 1/4"	91.4	89.2	86.8	84	81.4	78.2	75	71.3	67.6
7 1/2"	91.7	89.8	87.5	85	82.3	79.4	76.4	72.9	69.2
7 3/4"	92.3	90.5	88.3	86.1	83.5	81	78	75	71.3
8"	92.8	90.8	88.9	85.3	84.5	82	79.2	76.5	73.2
8 1/4"	93.1	91.3	89.2	87.8	85.5	83	80.8	77.7	74.7
8 1/2"	93.9	92.3	90.7	88.9	86.4	84.1	81.9	79.2	76.4
8 3/4"	94.1	92.5	91	89.5	87.1	85.1	82.9	80.3	77.8
9"	94.2	93	91.5	89.7	87.8	85.7	83.5	81.2	78

Lead 3/16"

Valve Travel \ Lap	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"
6"	86.9	83.8	80.2	76	72.3	67.4	62.7	57.3	51.7
6 1/8"	87.2	84.1	80.8	77	73.1	68.4	63.7	58.3	53.2
6 1/4"	87.5	85	81.6	78	74.3	70	65.2	60.2	55.3
6 3/8"	88.2	85.5	82.4	78.6	75.3	71	66.7	62	57
6 1/2"	88.7	86	83	79.4	75.8	71.9	67.8	63.1	58.7
6 5/8"	89.1	86.5	83.5	80.2	76.6	72.8	69.6	64.7	60
6 3/4"	89.6	87	84	81	77.8	74.1	70.4	66.2	61.3
6 7/8"	90	87.5	84.6	81.8	78.5	75	71.3	67.2	62.7
7"	90.4	88	85	82.3	79.6	75.8	72.4	68.4	63.7
7 1/4"	91	88.6	86.4	83.6	80.7	77.6	74.3	70.7	66.8
7 1/2"	91.4	89.6	87.1	84.6	81.7	78.9	76	72.5	68.3
7 3/4"	91.9	90.1	87.9	84.5	83	80	77.4	74	70.5
8"	92.5	90.6	88.6	86.3	84.1	81.6	78.8	75.9	72.6
8 1/4"	93	91.2	89.1	87.2	85.1	82.8	80	77	74.3
8 1/2"	93.4	91.8	90	88.1	86.2	83.9	81.2	78.3	75.6
8 3/4"	93.7	92.1	90.8	88.8	86.6	84.2	81.8	79.8	77.1
9"	94	92.5	91.1	89.2	87.5	85.4	83.1	80.7	78.2

Lead 1/4"

Valve Travel \ Lap	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"
6"	85.9	82.5	79.2	75	71	65.8	61.2	55.4	50.1
6 1/8"	86.2	83.4	79.9	75.8	72.3	67.4	62.6	57.2	51.6
6 1/4"	86.8	84	80.5	76.6	72.9	68.6	64	58.8	54
6 3/8"	87.5	84.5	81.4	77.8	74.4	70	65.6	60.4	55.8
6 1/2"	87.9	85.3	82.2	78.5	75.2	71.2	66.8	62	58.1
6 5/8"	88.4	85.8	82.6	79.3	75.5	71.7	68	63.8	58.7
6 3/4"	89	86.3	83.4	79.9	76.8	72.6	69	64.8	60.1
6 7/8"	89.3	86.8	83.8	80.8	77.5	74	70.3	66	62
7"	89 1	87.2	84.6	81.7	78.6	74.6	71	67.3	62.8
7 1/4"	90.2	88	85.6	82.8	80.3	76.8	73.5	69.9	65.9
7 1/2"	90.8	88.7	86.5	83.7	81	77.9	74.6	71.2	67.5
7 3/4"	91 3	89.3	87 1	84.6	82	79.2	76.2	73	69.8
8"	91.9	90.2	88	85.7	83.3	80.8	77.9	75	71.7
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8 1/2"	93	91.2	89.9	87.8	85.4	82.5	80.7	77.9	74.9
8 3/4"	93.2	91.6	90	88.2	86.4	84	81.8	79.1	76.3
9"	93.9	92.4	90.8	88.9	86.9	85	82.7	80.3	77.8

Lead 5/16"

Valve Travel \ Lap	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"
6"	85	81.5	78.2	73.4	69.6	64.7	59.6	541	48.4
6 1/8"	85.7	82.6	78.8	74.6	70.9	66.3	61.3	55.5	50.4
6 1/4"	86	83	79.6	76	72	67.6	62.9	57.4	52.5
6 3/8"	87	84	80.3	77	73	68.6	64.3	59.1	54.2
6 1/2"	87.4	84.4	81.2	77.5	74	69.8	65.6	60.6	56.2
6 5/8"	87.7	85.1	82	78.5	75.1	70.9	66.8	62.3	57.4
6 3/4"	88.2	85.6	82.5	79.1	75.9	72	68.2	64	59
6 7/8"	88.8	86.3	83	80.1	76.8	73.2	69.4	65.2	60.7
7"	89 1	87	83.4	80.5	77.6	74	70.5	66.3	61.8
7 1/4"	89.7	87.6	85	82.4	79.4	75.9	72.5	69	64.9
7 1/2"	90.4	88.3	85.6	83.1	80.2	77.3	75	70.6	66.6
7 3/4"	90.9	88.7	86.7	84.2	81.8	78.8	75.6	72.1	68.5
8"	91.6	89.6	87.5	85.1	82.8	80.2	77 1	74.3	70.7
8 1/4"	92.2	90.2	88.1	86	84.1	81 1	78.8	75.9	72.8
8 1/2"	92.6	91	89	86.8	84.4	82.3	79.5	77	74.2
8 3/4"	93	91.5	89.6	87.9	85.5	83.3	80.9	78.3	75.6
9"	93.3	92	90.3	88.4	86.5	84 4	82.1	79.8	77

FIG. 2

DEFINITIONS OF TERMS

The following terms are treated specifically in their relation to a locomotive steam engine. They are so interdependent one upon another, that the definition of each must presuppose some knowledge of the meaning of other terms used for defining them, therefore the explanations should be considered first collectively and then individually.

Cylinder: Is an internally circular body of uniform diameter, enclosing space for the reception of steam.

Piston: Is a movable partition, for separating the space in opposite ends of a cylinder.

Cylinder Clearance: Is the space between a piston, when at either extreme position, its nearest cylinder head and valve. It includes all space bounded by these three members. It is measured by volume and is designated by its percentage to the total cylinder volume displaced by one piston stroke. To illustrate: Eight per cent cylinder clearance means eight per cent of the sum obtained by multiplying the area of a piston by its stroke.

Piston Clearance. Is the distance between a piston, when at either end of its stroke and its striking position against its nearest cylinder head.

Steam Chest or Valve Chamber: Is an enclosed steam reservoir, in which a valve is operated.

Port: Is the opening of a communicating passage between a steam chest and cylinder, over which a valve is operated.

Valve (Distribution): Is a sliding member designed to open and close a port at each end of a cylinder. It permits alternate inlet and outlet of steam and distributes piston pressures.

Steam Distribution: Is the action of consecutive piston pressures.

Mean Effective Pressure (M.E.P.): Is the average net pressure which propels a piston during its entire stroke.

Valve Gear (Commonly, but incorrectly, termed valve motion): Is the mechanism employed for actuating a valve.

Valve Motion: Is the cyclic recurrence of valve events. The movement that causes a continuous series of events.

Valve Motion (Constant component of): Is the mechanically controlled minimum valve travel. Travel each way from mid position equal to lap and lead.

Valve Motion (Variable component of): Is the manually controlled maximum, intermediate and direction of valve travel that may be varied to suit service requirements.

Mid Gear: Is the position at which a valve gear causes minimum valve movement, and consequently minimum cylinder power. In this position a locomotive will not usually start itself, but it may start in either direction, forward or backward, and it will then continue to move in the same direction.

Full Gear: Is the position at which a valve gear causes maximum valve movement, and consequently maximum cylinder power. This position insures the greatest reliability for starting. The direction of starting movement is positively predetermined by placing in either full gear forward, or full gear backward.

Running Cut-Off: Is the operating cut-off necessary to maintain normal speed. Preferably at about 25 per cent in passenger and 33 per cent in freight service. These cut-offs produce valve events that insure economical steam consumption, but in large cylindered locomotives using standard valve gears later cut-offs are usually necessary and consequently the highest degree of economy is seldom attained.

Steam Lap: Is the distance the steam edges of a valve, when in mid-position, overlap the ports.

Steam Lap (Function): It causes expansion and pre-release.

Exhaust Lap: Is the distance the exhaust edges of a valve, when in mid position, over-lap the ports.

Exhaust Clearance (Sometimes termed exhaust lead): Is the width of port uncovered by the exhaust edges of a valve, when in mid position. In this position both cylinder spaces, partitioned by a piston, are in communication.

EXHAUST CLEARANCE (Function): It shortens expansion, reduces compression, and increases exhaust opening.

Port Opening (Steam - Exhaust): Is the width of opening to or from a cylinder, caused by a valve when at its extreme positions. In full gear a valve usually overtravels the ports; but it is customary to measure the over-traveled portion together with the port width.

Lead: Is the width of steam port opening at the beginning of the piston stroke.

Lead (Function): It causes pre-admission and consequently corrects insufficient or excessive compression. It insures high initial piston pressure. It decreases liability of injury from wet steam or water.

Lead (Constant): Is the same in all cut-offs, forward and backward motions.

Lead (Variable): Is greater in earlier cut-offs, forward and backward motions.

Lead (Crossed): Is least in full gear forward, greatest in full gear backward.

Valve Travel: Is the reciprocal movement of a valve; its maximum movement unless otherwise designated.

Valve Events: Are the periods during its travel when the valve and port edges register. They are the points of piston stroke at which pre-admission, cut-off, release and closure occur.

Pre-admission (Point of): Is the point at which the steam edge of a valve begins to open the port before the piston has completed its stroke. It is caused by lead, is fixed by the amount of lead and is advanced by the shortening of cut-offs. It is measured by the amount of unfinished piston movement.

Pre-admission (Function): It equalizes pressures between a steam chest and cylinder, at or near the completion of the piston stroke.

Cut-off (Point of): Is the point at which the steam edge of a valve closes the port.

Cut-off (Function): It terminates admission and begins the expansion period.

Cut-off (Percent of): Is its percentage of piston stroke, measured by the completed piston movement at the time cut-off occurs.

Cut-off (Early-Short-High): Occurs early in the piston stroke.

Cut-off (Late-Long-Low): Occurs late in the piston stroke.

Cut-off (Maximum): Is the latest obtainable.

Release (Sometimes termed pre-release) Point of: Is the point at which the exhaust edge of a valve begins to open the port before the piston has completed its stroke. It is advanced by the shortening of cut-offs and is measured by the completed piston movement at the time release occurs.

Release (Function): It terminates expansion and begins the exhaust period.

Closure (Point of): Is the point at which the exhaust edge of a valve closes the port. It is advanced by the shortening of cut-offs, and is measured by the unfinished piston movement at the time closure occurs. If a valve has neither exhaust lap or clearance, release and closure occur at identical piston positions.

Exhaust lap retards release and advances closure.

Exhaust clearance advances release and retards closure.

Closure (Function): It terminates exhaust and begins the compression period.

Positive Pressure: Is the pressure tending to move a piston.

Negative Pressure: Is the pressure tending to check the movement of a piston.

Admission: Is the act of applying positive pressure to a piston. It is accomplished by communication between a steam chest and cylinder, caused by steam port opening. Its technical duration is from the beginning of the stroke to the point of cut-off and it is manually controlled. Its object is to supply steam to a cylinder. Admission is a continuation of the act of pre-admission, but admission causes positive pressure, pre-admission negative pressure.

Expansion: Is the act of continuing positive piston pressure beyond an admission period. It is accomplished by valve lap, which permits a cut-off mass of steam to increase in bulk and relatively decrease in pressure. Its duration is from the point of cut-off to that of release; is prolonged by the shortening of cut-offs; and is affected by the amount of steam and exhaust lap or clearance. Its object is to economically utilize the expansive properties of steam.

Exhaust: Is the act of reducing piston pressure. It is accomplished by communication between a cylinder and the atmosphere and is caused by exhaust port opening. Its duration is from the point of release to the end of the piston stroke, which constitutes one stage for reducing positive pressure and from the beginning of the return stroke to the point of closure, another stage for reducing negative pressure. It is advanced by the shortening of cut-offs, but is not hereby prolonged or shortened except by a valve with exhaust clearance, or exhaust lap. Its object is to discharge expanded steam.

Compression: Is the act of increasing negative piston pressure. It is accomplished by terminating communication from a cylinder, and is caused by exhaust port closure. Its duration is from the point of closure to that of pre-admission. It is advanced and prolonged by the shortening of cut-offs and is affected by exhaust lap or clearance. Its object is to economically produce initial pressure for the return piston stroke and consequently reheat piston and cylinder surfaces. It absorbs condensation and also acts as a cushion to absorb the momentum of reciprocating parts.

Valve Ellipse (Motion curves): Is an oval diagram illustrative of valve movement. Its length represents piston stroke. Its width, valve travel. As usually shown, its length is proportionate to one-half its width, that is, if representing a 28-inch stroke and 8-inch valve travel the ellipse will be 14 inches long and 8 inches wide. If reduced in size these relative proportions are maintained. A straight longitudinal center line represents central valve position. A parallel line each side, but near the center line, indicates exhaust lap or clearance. Another parallel line each side, but at greater distance, shows the steam lap. The points at which the elliptical lines cross the lap lines are the points of pre-admission and cut-off, and where they cross the exhaust lines are points of release and closure. If a valve has exhaust lap, closure occurs earlier in the stroke than release. If exhaust clearance, release is earlier. The widths of the steam port openings are the distance of the elliptical lines outside of the lap lines, and of exhaust port openings, their distances from the exhaust lines. Fig. 3 shows an ellipse taken at two reverse yoke positions, full gear and running cut-off, indicating the points of pre-admission, cut-off, etc.

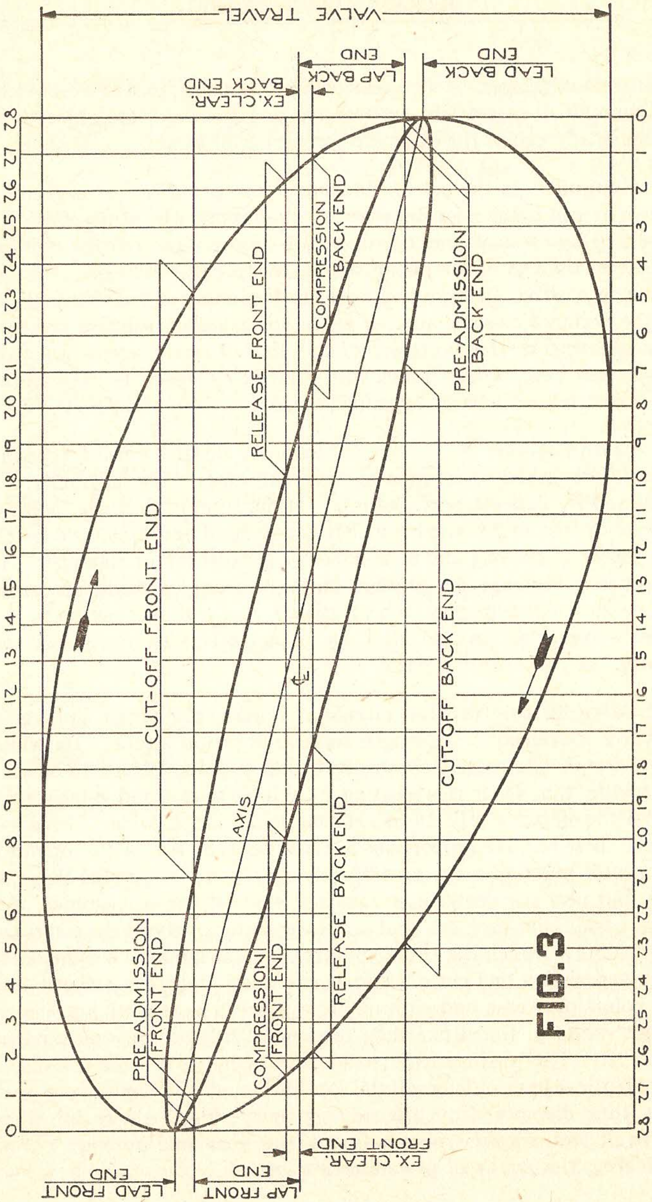

VALVE TRAVEL
LEAD BACK END
LAP BACK END
EX. CLEAR. BACK END
COMPRESSION BACK END
PRE-ADMISSION BACK END
RELEASE FRONT END
CUT-OFF FRONT END
CUT-OFF BACK END
AXIS
RELEASE BACK END
PRE-ADMISSION FRONT END
COMPRESSION FRONT END
EX. CLEAR. FRONT END
LAP FRONT END
LEAD FRONT END
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

FIG. 3

Indicator Card: Is a diagram for measuring piston pressures. Its lines are automatically registered by an instrument attachable to a cylinder and provided with means for recording positive and negative pressures at all piston positions.

Wheel Center (Dead center): Is the position of a driving wheel when a straight line from the center of a wrist pin in a crosshead, through the center of a driving wheel, intersects the center of a main pin (crank pin). In this position a crosshead is at one extremity of its stroke. It is termed "dead" because positive piston pressure can cause no rotative impulse.

Top Quarter, Bottom Quarter: Is the position of a crank pin, midway between dead centers, above or below.

Mid Position: Is half-way between two extremes. For a crosshead, one-half of its stroke; for reverse yoke, gear connecting rod or link, one-half of its swing; for a radius bar, half-way between its extreme positions, when the link block pin and link trunnions are concentric.

THE INDICATOR CARD

Figure 3-A shows the relations between a valve, port and piston, during one stroke, at 50 per cent cut-off. Steam action is designated by arrows. Admission in heavy full lines. Expansion in heavy broken lines. Exhaust in light full lines and compression in light broken lines.

Indicator diagrams are illustrated by heavy lines and show distribution for both ends of a cylinder or a complete wheel revolution.

Indicator cards are drawn by a continuous line of six divisional elements. From the beginning of a stroke to the point of cut-off is the steam line, caused by admission. Thence to the point of release is the expansion line, caused by expansion. To the end of the stroke is the exhaust line, caused by the first exhaust stage. On the return stroke to the point of closure is the back pressure line, caused by the second exhaust stage. To the point of pre-admission is the compression line, caused by compression and to the end of the stroke is the admission line, caused by pre-admission.

In the illustration only one stroke is shown; therefore, while it records positive pressure (the upper line) on one card, and negative pressure

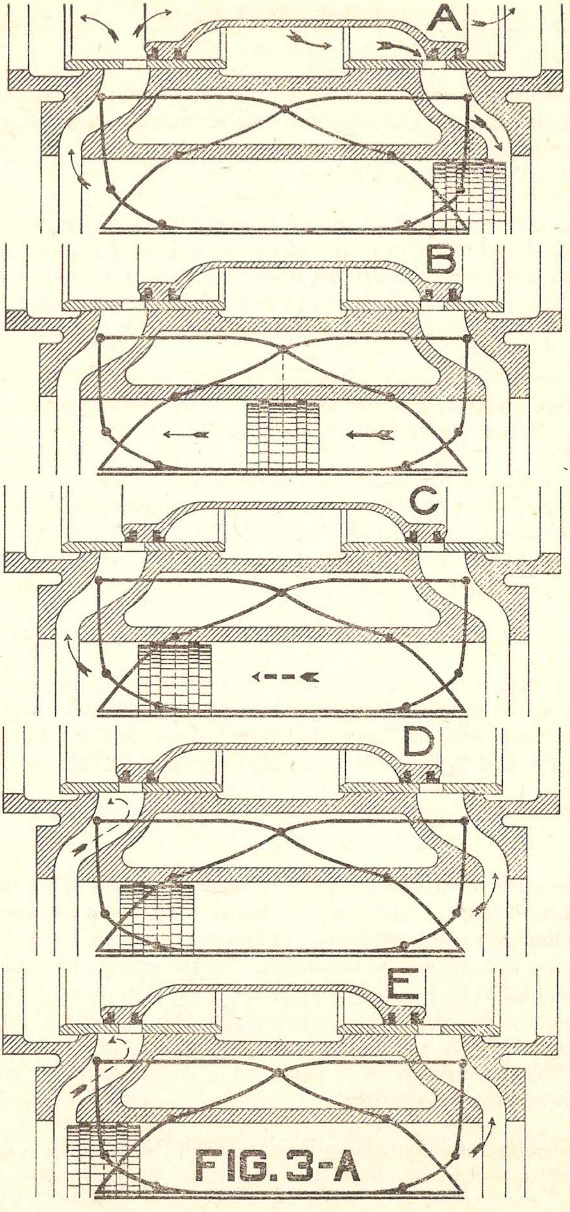


FIG. 3-A

(the lower line) on the other, the first three piston positions mark the events on the right hand card, and the last two on the left hand card. An illustration showing the return stroke would complete both cards.

The length of these cards represent piston stroke and their height pressure per square inch. The lower straight horizontal lines are the lines of assumed atmospheric pressure; they are the base lines for measuring height.

Assuming that a one hundred-pound spring was used in the instrument with which these diagrams were drawn, and that the cards were full size, the height above atmosphere of their upper lines, at any point, would represent one hundred pound per square inch, positive pressure against a piston at that point, for each inch of height. The height of their lower lines at any point would represent negative pressure.

The areas enclosed are work diagrams. The amount of work performed is calculated from the breadth of the areas. The average distances between the upper and lower card lines are mean effective pressures, convertible into kinetic energy for transmission to mechanical parts. The distances between the back pressure and atmospheric lines are back pressure and between the compression and atmospheric lines are compressions.

A. Illustrates the valve position at the beginning of the act of admission. It does not register an event, but it terminates the blending process of pre-admission into admission because of valve lead. The piston is at the beginning of its stroke. The maximum height of the card, indicating initial pressure, is at this point.

B. Is the position at the point of cut-off and constitutes a valve event. It causes the beginning of the act of expansion. On the card it terminates the steam line. Due to gradual port closure this line always lowers toward its termination.

C. Shows the position at the point of release. It is the event that causes the beginning of the act of exhaust. On the card it terminates the expansion line and begins the exhaust line which should drop approximately to the atmospheric line at the end of the stroke, in order to insure low initial back pressure.

D. Indicates the position at the point of closure. This event causes the beginning of the act of compression. On the card it terminates the back pressure which is usually higher at its termination than at its beginning, because of the gradual exhaust port closure. Its height increases with increasing piston speed.

E. This position is the point of pre-admission. It is the event that causes the beginning of the act of pre-admission. On the card it terminates the compression line and begins the admission line. Its height should be less than that of the steam line.

PRINCIPLE OF OPERATION

Inside Admission. The action of the Baker Valve Gear may best be learned by tracing the movement of the valve through a complete revolution of the wheels. Figures 4 and 5 show a series of diagrams representing the different positions of the crank pin. For the sake of simplicity, the valve and cylinder are shown in section. The other parts of the gear are represented by their center lines only. These diagrams are purposely drawn out of proportion. The valve has been enlarged in order to show more clearly the positions of the edges of the valve, relative to the edges of the cylinder ports.

Figures 4 and 5 represent the Baker Valve Gear as arranged for piston valves inside admission.

Forward Motion, Full Gear: Figure 4, Diagram 1, illustrates the engine with the reverse lever in full forward motion. The engine is represented as being on the back dead center. As the wheel is rotated in the direction of the arrow, the eccentric rod moves away from the cylinder, carrying with it the gear connecting rod to which it is coupled. This produces a movement of the radius bars also away from the cylinder, which in turn sets up a lifting action on the horizontal arm of the bell crank, thus moving the valve backward. This operation continues until the crank pin practically reaches the top quarter, when the eccentric movement reverses (because of the action of the eccentric crank) with the result that the valve starts to close.

Figure 4, diagram 2, shows the valve in the act of closing the rear cylinder port or in the position of crank end cut-off. As the wheel continues to rotate in the direction of the arrow beyond the point shown in diagram 2, the eccentric rod, connecting rod and radius bars produce a downward movement on the horizontal arm of the bell crank, thus continuing to move the valve toward the front, until the engine reaches

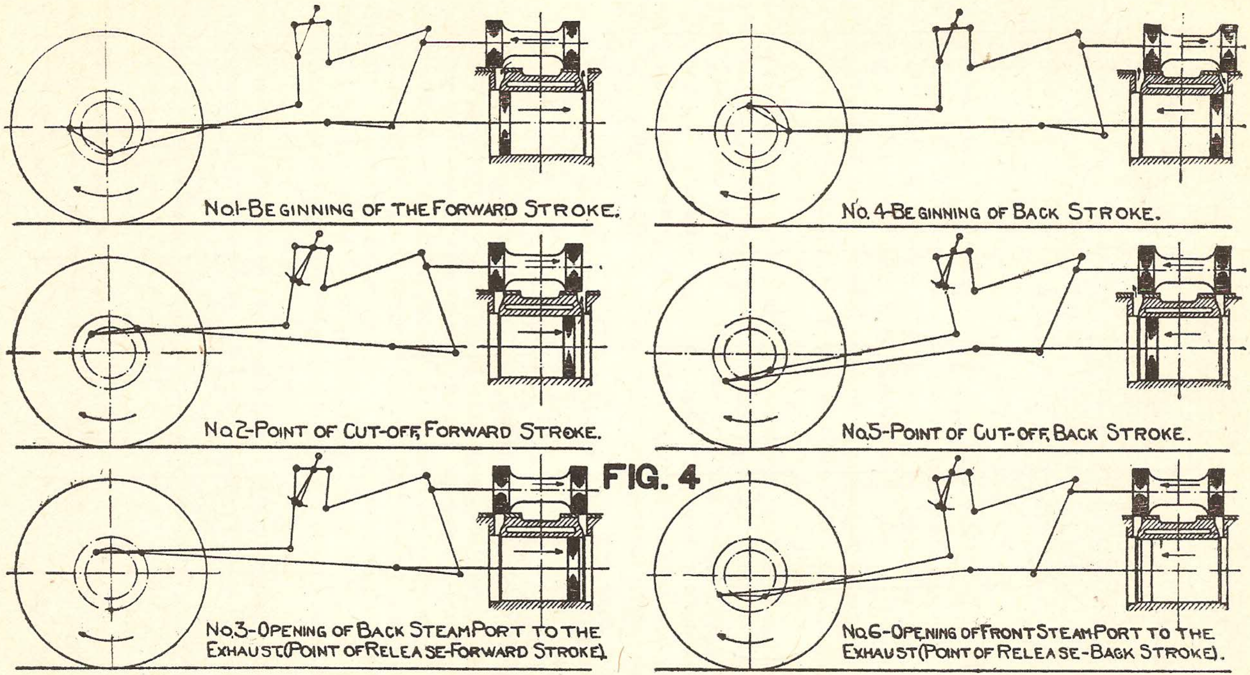
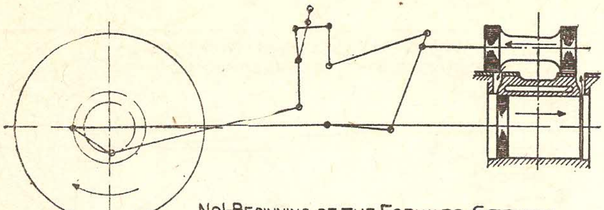
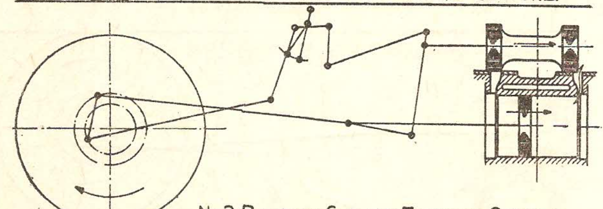

No.1-Beginning of the Forward Stroke.
No. 4-Beginning of Back Stroke.
No.2-Point of Cut-off, Forward Stroke.
No.5-Point of Cut-off, Back Stroke.
No.3-Opening of Back Steam Port to the Exhaust (Point of Release-Forward Stroke).
No.6-Opening of Front Steam Port to the Exhaust (Point of Release-Back Stroke).

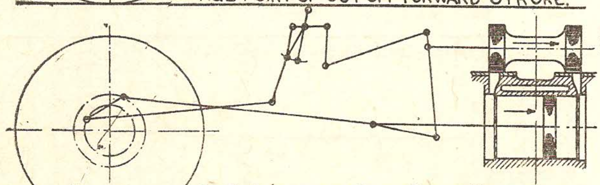
FIG. 4



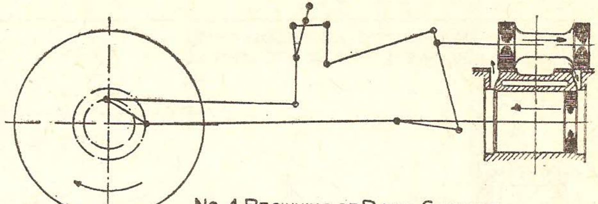
No.1-Beginning of the Forward Stroke.



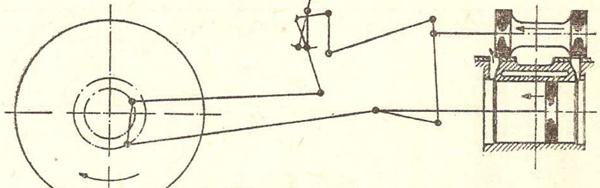
No.2-Point of Cut-off Forward Stroke.



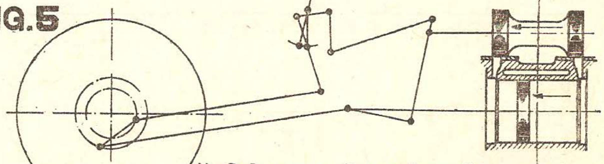
No.3-Opening of Back Steam Port to the Exhaust. (Point of Release-Forward Stroke).



No. 4-Beginning of Back Stroke.



No.5-Point of Cut-off, Back Stroke.



No.6-Opening of Front Steam Port to the Exhaust. (Point of Release-Back Stroke).

FIG. 5

practically the bottom quarter, when the direction of movement of valve is again reversed in the manner described above. From the description it will be noticed the Baker Valve Gear, inside admission, is direct in forward motion; that is, the valve moves in the same direction as the eccentric rod.

Forward Motion Running Positions. The position of the reverse yoke governs the amount of valve travel and also the percentage of cut-off obtained. As the reverse yoke is brought nearer its mid-position the arc of the radius bars becomes more nearly horizontal and produces a less upward and downward movement of the horizontal arm of the bell crank, thus decreasing the valve travel.

Figure 5 shows the engine in the same position as Figure 4, with the exception that the reverse yoke has been brought nearer to mid gear position, and shows the effect on the various valve events of "hooking up" the reverse yoke. For example, it will be noticed that (in Figure 5) the valve cuts off the steam from the cylinders and opens the ports to the exhaust at a much earlier period in the piston stroke than it does in Figure 4.

Backward Motion. The reversing of the Baker Valve Gear is accomplished by bringing the radius bar bearings in the reverse yoke past the mid gear position, away from the bell crank. The effect of this is to change the arc of the radius bar. The movement of the eccentric rod away from the cylinder then produces a downward action on the upper arm of the bell crank, causing the valve to come forward. This is just the opposite to the effect of this eccentric rod movement with the reverse yoke in forward motion. The inside admission gear is therefore indirect in back motion; that is, the valve moves in a direction opposite to the movement of the eccentric rod.

Mid-Gear Position. The Baker Valve Gear is in mid-position when the centers of the reverse yoke and radius bar bearing bell crank and gear connecting rod bearing, gear connecting rod and radius bar bearing are on a common center line through the middle of the reverse yoke and gear frame pin.

Lap and Lead Movement. The lap and lead movement is obtained from the combination lever by simply proportioning this lever so that when its long arm receives a movement equal to the piston stroke, its short arm will deliver to the valve a movement equal to two times the sum of the lap plus the lead. This movement is separate from and entirely independent of the rest of the valve gear action and, therefore, remains constant, regardless of the reverse yoke or the reverse lever position.

To Change the Lead. To change the lead of the Baker Valve Gear, it is necessary to change either the lap of the valve or the distance between the connecting points of the combination lever. Reducing the lap of the valve increases the lead, and vice-versa. Changing the lap also changes the point of cut-off. The effect of reducing the lap is therefore not only to increase the lead, but also to increase the point of cut-off. The effect of increasing the lap is just the opposite. To increase the lead by means of a change in the combination lever, it is necessary to make the upper arm longer or the lower arm shorter. To decrease the lead these changes are just the opposite.

Rules. The reverse yoke moves forward in the forward motion.

The eccentric crank follows the main crank pin in the forward motion and leads it in backward motion.

Combination levers for inside admission valves have the valve stem attached below the valve rod connection.

Combination levers for outside admission have the valve stem attached above the valve rod connection.

VALVE SETTING

Object to be Accomplished. The object to be accomplished is to adjust the valve gear so that Admission, Cut-off and Release will occur at correct intervals; that the engine will exert an even, continuous effort and thus be economical in the use of steam. The maximum valve travel, lap, lead and exhaust clearance are determined by the designer and should not be altered except on proper authority. The best practice is to judge the quality of the valve setting by the uniformity of the Cut-Offs on front and back on both sides of the engine for any one position of the reverse lever.

Recommended Practice. In setting valves it is best to follow a certain definite program, adjusting each part in logical order. The method herein described has been found by The Pilliod Company to be the best adapted to meet all conditions. Experienced valve setters may prefer other methods, but the following is recommended for their consideration.

Operation. In general the operations should follow one another in the manner here submitted.

1st—Assembly.

2nd—Checking valves and bushings to see that they are to the proper dimensions and the bushings properly located in the steam chest.

3rd—Port marks and dead centers.

4th—Location of eccentric crank.

5th—Adjustment of valve rod, eccentric rod, and eccentric crank.

6th—Adjustment of full gear valve travel.

7th—Checking of cut-off, making any slight adjustments to correct same.

8th—Valve motion report, when called for.

9th—Applications of stops, aligning of rods, applying nuts, cotter pins, etc., and generally finishing the work.

Assembly. The valve should be assembled according to des ign The valve, valve seat or bushings, valve stem, combination lever, union link, eccentric crank, reverse shaft arms and gear parts (gear frame, reverse yoke, radius bars, gear connecting rod and bell crank) should be exactly to design and no alterations should be made on any of these parts. Reverse shaft arms and reverse lever or power reversing gear should be placed in mid-gear position and main reach rod made of a length to suit. The main wheel center should be located at specified distance from top of engine frame.

Trams. A standard valve stem, wheel and crosshead tram should be used on locomotives of the same class, or as many classes as possible. This will avoid confusion and facilitate the valve setting.

Figures 8 and 8A illustrate convenient types of valve stem trams (See Page 27). When the port marks are scribed on the stem with tram shown in Figure 8, the marks will be reversed; that is, the front steam port marks will be on the back end of the stem and the back steam port marks on the front end. The exhaust port marks will also be reversed. However, if tram shown in Figure 8A is used, the front steam port marks will be toward the front of engine and the back steam port marks will be toward the back. In all of the examples shown on the pages which follow the port marks were scribed with a tram, as shown in Figure 8 and are reversed.

Port Marks. The term "Port Marks" is usually taken to mean lines scribed on the valve stem to show the point of valve opening (Admission) or closing (Cut-Off) on the steam edge. Port marks made to designate the opening (Release) and closing (Compression) of the valve on the exhaust edge are called "Exhaust Port Marks".

Piston valve cylinders are usually provided with peep holes, through which the edges of the valves andcylinder ports can be seen. To obtain the port marks, place the steam edge of the valve, line and line with the steam edge of the port in the bushing; with a tram scribe the valve stem as shown in Figure 8 or Figure 8A (See Page 27).

The exhaust port marks can be obtained in the same way by placing the exhaust edge of the valve line and line with the exhaust edge of the ports in the bushings.

In the case of slide valve cylinders the steam chest covers are usually removed and the port marks obtained the same as above. Here, however, the exhaust port marks must necessarily be laid out, as the exhaust edges are invisible when the valve is on its seat.

The port marks should be clearly scribed on the stem or any other convenient location, such as the valve stem crosshead guides or cylinder jacket. It is customary to make these lines longer than those showing the port openings in order to avoid confusion.

Dead Centers. In order to accurately adjust the valve setting, it is necessary to determine when the piston is exactly at the ends of the stroke. At these points the centers of the crosshead wrist pin, main crank pin and driving wheel are in a direct line. These points are obtained as follows: Rotate the wheel until the crosshead is about ½" from the end of the stroke. With any tram of convenient length from a center conveniently located on some stationary part, as the engine frame, scribe a line across the edge of the driving wheel tire. With the same or another tram, from a center point on the main crosshead, scribe the guide. Rotate the wheel slowly holding the crosshead tram in the crosshead mark, until the other end passes by the previously scribed mark on the guide bar, then reverse the rollers to rotate wheel

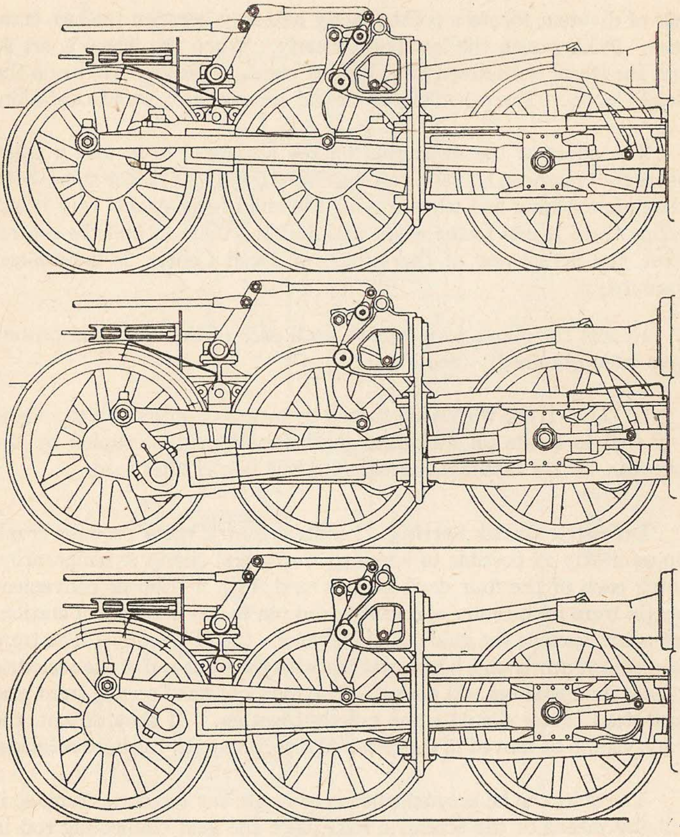


FIG. 6

in opposite direction until the tram drops exactly into the mark on the guide. Mark driving wheel tire again as above (the motion of the wheel is reversed at this point to absorb the slack in the main rod and boxes, or so the main rod will move in the same direction while the marks on the guide are being obtained). With a pair of oddleg calipers set about one-half the thickness of the tire, draw a line parallel to the wearing face of the tire so as to cross both of the lines just scribed. With a pair of dividers, locate a point exactly half way between the two tram lines. Prick punch the last point clearly. When the wheel is set so that the wheel tram drops into this last point, the engine will be on the Dead Center. The other marks should be erased to avoid confusion.

The effect of the measuring on the crosshead is to find a point where the crosshead travel (from the end of the stroke) is the same, both when approaching and when leaving the end of the stroke. By transferring these points to the wheel and dividing them to find the central point, the actual end of the stroke, or Dead Center, is determined absolutely.

Repeat the above performance until each of the four dead centers have been obtained. (See Figure 6).

NOTE: If the wheels are turned by means of power-driven rollers, it is well to locate all the wheel marks on the side occupied by the operator, for his assistance in catching the marks afterward.

Eccentric Crank Setting. Locate eccentric crank on main crank pin as nearly as possible to specified throw and clamp it temporarily. Catch each of the four dead centers and with a tram of convenient length, tram from center of eccentric rod pin to any convenient stationary point, such as the guide or guide yoke. (See Figure 7). The tram should be as nearly on a horizontal line with the front end of the eccentric rod as circumstances will permit. The lines obtained on the front and back dead center should come exactly together. If they do not, the crank should be moved in the required direction until the lines coincide.

The object to be accomplished is to locate the eccentric crank so it will (by means of the eccentric rod) place the gear connecting rod in exactly the same point on each dead center. This is essential, for otherwise it is impossible to obtain the same lead condition on both front and back dead centers and in both forward and backward motion. Having set the eccentric crank as explained above, no further change should be required, and it can be permanently secured. While this work is being done, it is good practice to check the crank throw at the same time.

Valve Rod and Eccentric Rod Adjustments. The errors in these rods manifest themselves by distorting the entire steam distribu-

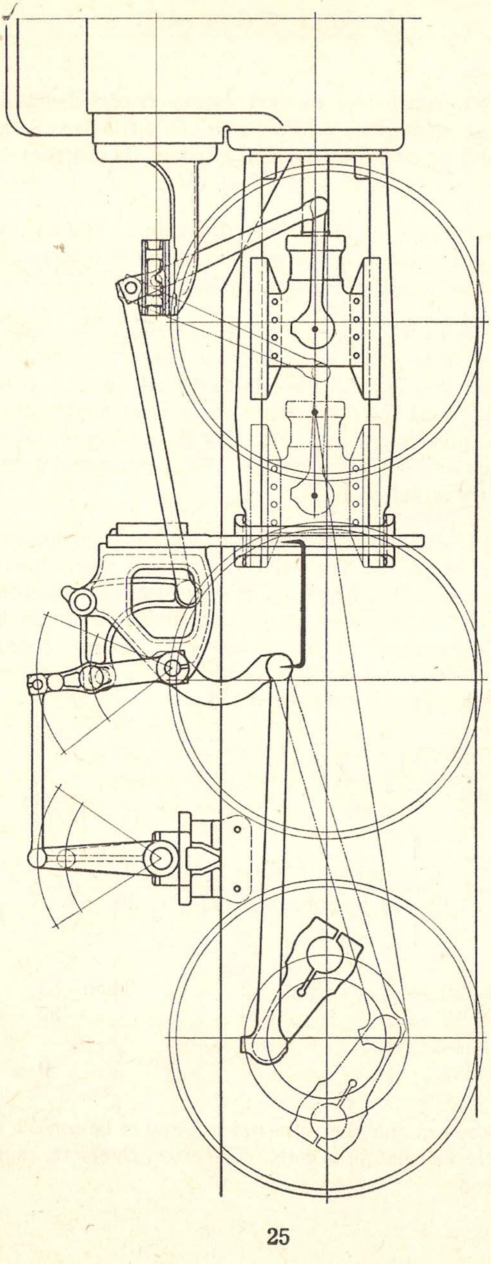


FIG.7

tion. The most convenient method, however, of calculating these errors is through their effect on the lead. The methods here described have been found generally satisfactory, although there are several other good ways.

Place the reverse lever in full forward position. Rotate the wheels forward and catch successively each of the four dead centers and scribe the valve stem to show the lead at each dead center.

NOTE: Scribe all forward motion lines above the center line of the valve stem, and all back motion lines below the center line to avoid mistakes. (See Fig. 12). We suggest marking the port openings in sixty-fourths, using the numerator only as illustrated in the following examples, instead of $\frac{5}{16}''$, $\frac{3}{16}''$, etc. The port marks in the examples that follow were scribed on the stem, so they are reversed as explained in a previous paragraph.

Example 1. Assuming the condition that has been obtained to be represented by Figure 8. The valve rod error is determined first as follows: Add the leads on one end and the leads on the other end; subtract the smaller from the greater and divide the result by four. The result of this calculation is the amount of change necessary to correct the valve rod and is always made in a direction necessary to correct the greater or controlling error. As:

Front Port Marks		Back Port Marks	
20	Forward Motion Leads	12	Front of Engine
12	Backward Motion Leads	20	

As		And		Then	
	20		12		32
	+12		+20		—32
	32		32		0

In the above example the valve rod is found to be correct, because the result of the calculatoin is zero. The error, therefore, must be in the eccentric rod.

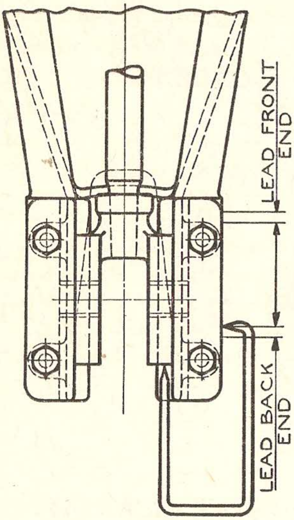


FIG.8-A

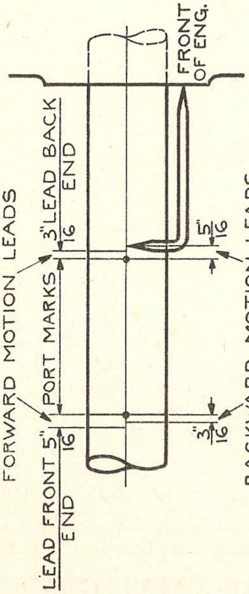


FIG.8

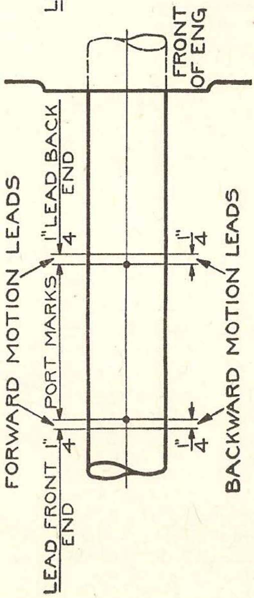


FIG.9

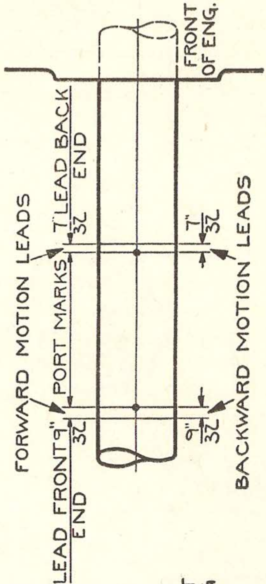
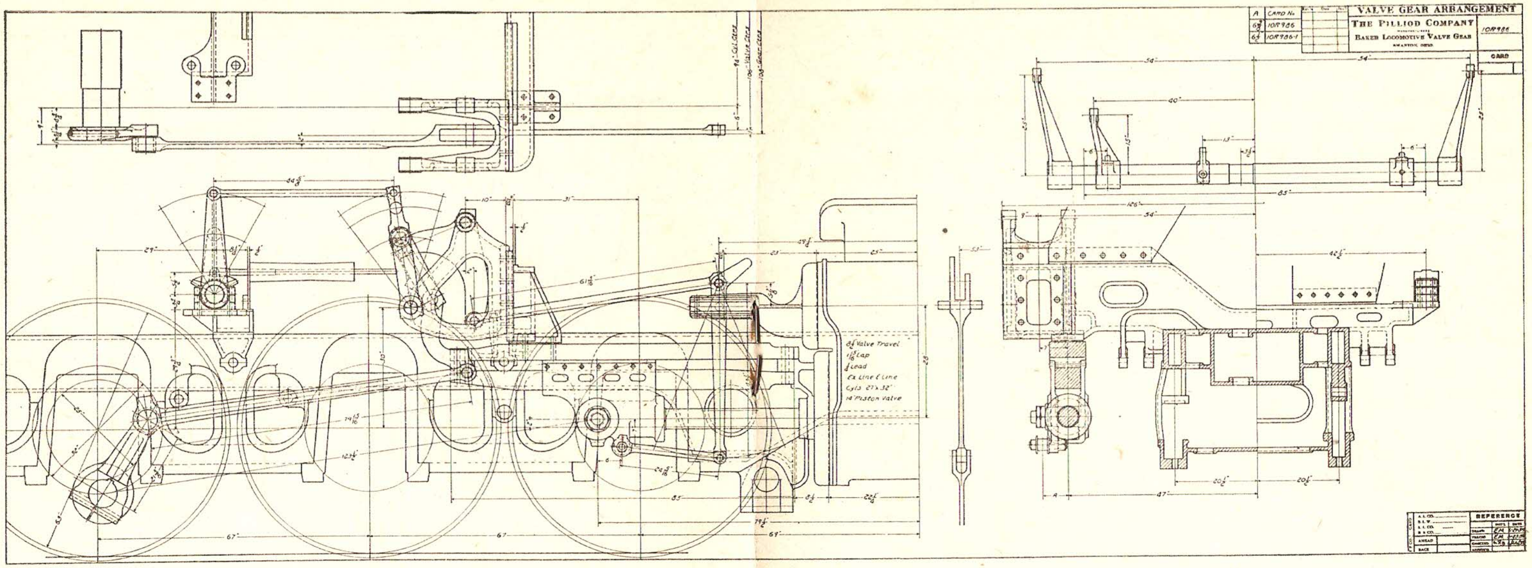
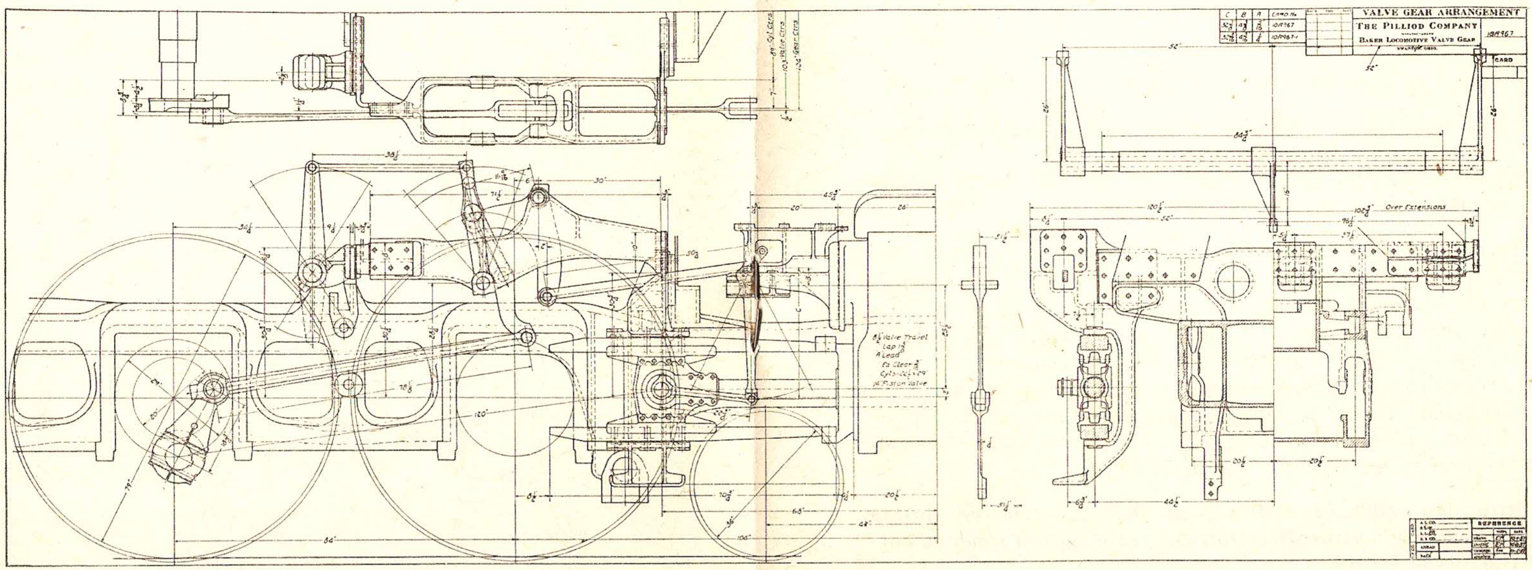


FIG.10



BAKER VALVE GEAR APPLICATION WITH TRIANGULAR GEAR FRAME



BAKER VALVE GEAR APPLICATION WITH LONG GEAR FRAME

Example 2. Eccentric rod error is determined as follows: Subtract the lead on one end in one motion from the lead on the opposite end in the same motion and divide the result by two. This gives the amount the valve must be moved to correct the reading. The ratio of the Baker Standard Gear is four to one in full gear, while the Long Lap and Long Travel Baker Gears have a ratio of three to one at full travel; that is, the eccentric rod must be changed four times the amount of the required valve movement for the Standard gear and three times the amount of valve movement for the Long Lap and Long Travel Gears.

Front Port Marks		Back Port Marks	
20	Forward Motion Leads	12	Front of Engine
12	Backward Motion Leads	20	

As 20 — 12 = 8 And 20 — 12 = 8

$8 \div 2 = 4$ Valve Movement

$4 \times 4 = 16$ or $\frac{16}{64}$ or $\frac{1}{4}''$ Eccentric Rod Change—Standard Gear

$4 \times 3 = 12$ or $\frac{12}{64}$ or $\frac{3}{16}''$ Eccentric Rod Change—Long Lap or Long Travel.

Therefore, the eccentric rod must be shortened $\frac{1}{4}''$ to produce a movement of $\frac{1}{16}''$ in the valve on the Standard Gear or the eccentric rod must be shortened $\frac{3}{16}''$ to produce a movement of $\frac{1}{16}''$ on the Long Lap and Long Travel Gears. As has been previously explained, the Baker Valve Gear is direct in forward motion and indirect in the backward motion; consequently, the change in the eccentric rod will move the valve in one direction in forward motion and in the opposite direction in backward motion. This change will, therefore, correct the example so it will read $\frac{1}{4}''$ all around. (See Figure 9).

Rule: On inside admission gears the eccentric rod should be changed in the same direction the valve should move to correct the forward motion.

Example 3. Assuming the condition obtained to be as represented by Figure 10. Calculate the valve rod change in the same manner as example No. 1.

Front Port Marks		Back Port Marks	
18	Forward Motion Leads	14	Front of Engine
18	Backward Motion Leads	14	

As 18	And 14	Then 36
+18	+14	—28
36	28	8

$8 \div 4 = 2$ or $\frac{2}{64}$ or $\frac{1}{32}''$ Valve Rod Change in direction to correct the greatest error, or in this case shortened, which will correct the entire reading so it will show 16 or $\frac{1}{4}''$ lead at all points as in Fig. 9; thus no change in the eccentric rod is required.

Note: These three examples are purposely made up in this manner to make clear the result of an error in either the valve rod or eccentric rod when one rod is correct. When the valve rod alone requires adjustment, it will be noted that the valve calls for a movement bodily in one direction. When the valve rod is correct and the eccentric rod is incorrect, the valve will require a movement in one direction to correct one motion, and in the opposite direction to correct the other motion.

Ordinarily in valve setting it will be found that the error is caused by a combination of valve rod and eccentric rod errors. When the method of calculating for adjustments is thoroughly understood, there should be no difficulty experienced in making the necessary corrections.

Example 4. Shows a combination of valve rod and eccentric rod errors, and the method of calculating for the adjustment.

Front Port Marks		Back Port Marks	
24	Forward Motion Leads	8	Front of Engine
4	Backward Motion Leads	28	

Valve Rod Adjustment. This adjustment is calculated first. To find the necessary change, add the leads on one end and the leads on the other end; subtract the smaller sum from the greater.

As 24 + 4 = 28   And 8 + 28 = 36   Then 36 — 28 = 8

$8 \div 4 = 2$ or $\frac{2}{64}$ or $\frac{1}{32}''$ Valve Rod Change in direction to correct greatest error, or in this instance lengthened.

The effect of this change makes the example read:

Front Port Marks		Back Port Marks	
26	Forward Motion Leads	6	Front of Engine
6	Backward Motion Leads	26	

This change, it will be noticed, has still further distorted the forward motion although it has improved the backward motion, but the error is now of the same amount in both motions and in the opposite directions.

Eccentric Rod Adjustments: Is determined as follows: Subtract the smaller lead in one motion from the larger in the same motion and divide the result by 2. This will be the amount the valve must be moved to correct error.

As 26 — 6 = 20   Or 26 — 6 = 20

$20 \div 2 = 10$ or $\frac{10}{64}$ or $\frac{5}{32}''$ Valve Movement

$\frac{5}{32} \times 4 = \frac{5}{8}''$ Eccentric Rod Change for Standard Gear

$\frac{5}{32} \times 3 = \frac{15}{32}''$ Eccentric Rod Change—Long Lap or Long Travel Gears.

Explanation: The above figures show that in forward motion the valve should be moved back $\frac{5}{32}''$ and in the backward motion the valve should be moved ahead $\frac{5}{32}''$ to square the lead.

The Baker Valve Gear is direct in forward motion and indirect in backward motion. Therefore, the effect of changing the length of the eccentric rod is to move the valve in one direction in forward motion and the opposite direction in backward motion. Consequently, shortening the eccentric rod a sufficient amount to move the valve $\frac{5}{32}''$ will correct the error in both motions and make the lead $\frac{1}{4}''$ on all four points. The eccentric rod on Standard Gear should be altered four times the required valve movement or $\frac{5}{32}'' \times 4 = \frac{5}{8}''$ or $\frac{5}{32}'' \times 3 = \frac{15}{32}''$ for Long Lap or Long Travel Gears.

Rules: Valve Rod: The valve rod change is always in the direction to correct the greatest error. Eccentric rod: On inside admission gears the change in the eccentric rod is always in the direction the valve should move to correct the forward motion.

Example 5. This shows a combination of valve rod and eccentric rod errors in which the valve fails to open the steam port on one end in forward motion.

Front Port Marks		Back Port Marks	
40	Forward Motion Leads	8	Front of Engine
24	Backward Motion Leads	8	

The back port marks in this case, when added together, cancel each other as the forward motion fails to open the port by $\frac{1}{8}''$ and the backward motion shows $\frac{1}{8}''$ open.

As	40	And	—8	Then	64
	+24		+8		—0
	64		0		64

$64 \div 4 = 16$ or $\frac{16}{64}$ or $\frac{1}{4}''$ which is the amount the valve will have to be moved back or in the direction to correct the greatest or controlling error. This change would then show port marks as follows:

Front Port Marks		Back Port Marks	
24	Forward Motion Leads	8	Front of Engine
8	Backward Motion Leads	24	

The eccentric rod adjustment would be—

$$\text{As } \begin{array}{r} 24 \\ -8 \\ \hline 16 \end{array} \qquad \text{Or } \begin{array}{r} 24 \\ -8 \\ \hline 16 \end{array}$$

$16 \div 2 = 8$ or $\frac{8}{64}$ or $\frac{1}{8}''$ Valve movement to make the leads read 16 or $\frac{1}{4}''$ at all points. To do this would require shortening the eccentric rod as follows:

$\frac{1}{8} \times 4 = \frac{1}{2}''$ with the Standard Gear.

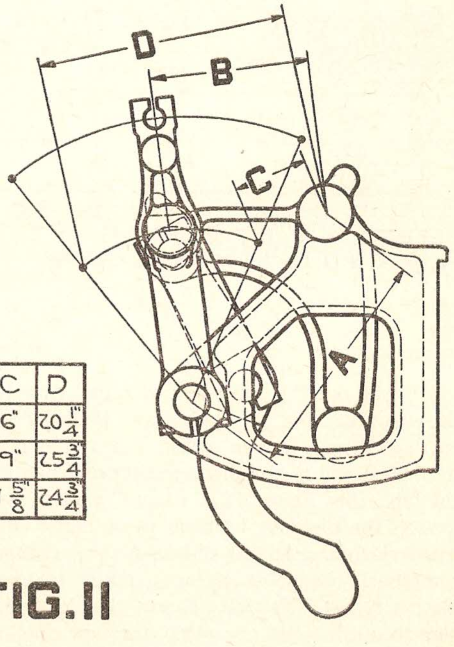
$\frac{1}{8} \times 3 = \frac{3}{8}''$ with the Long Travel or Long Lap Gears

The valve rod adjustment should always be determined first. When the changes in the valve rod and eccentric rod, as outlined above, have been made the lead should be measured on the four dead centers in each direction to check the work.

At the time of checking the leads the extreme travel points of the main crosshead should be marked on the guide, as these lines represent the extreme travel of the crosshead and are for use later when measuring the Cut-Off, Release and Compression.

Adjusting Full Gear Valve Travel: The full gear valve travel can be corrected and equalized between two sides of the engine while checking the lead, as above. The quadrant or power reverse gear should be laid out for extreme travel points. Set the stops on the power reverse quadrant in the cab so the reverse yoke will clear stop lug on frame by ¼″ when the maximum specified valve travel is produced. These lugs are for the purpose of providing a positive stop against creeping.

The full gear position of the reverse yoke for the standard gear should not be less than 6″ from the bell crank pivot in forward motion and not greater than 20¼″ in backward motion, as shown by Figure 11. For the long lap gear the distance between the bell crank pivot and center of reverse yoke should not be less than 9″ in forward motion and not greater than 25¾″ in backward motion. For long travel gear extreme yoke position is 7⅝″ in forward motion and 24¾″ in backward motion. These figures should be checked after the boiler has been fired up to correct errors caused by boiler expansion. Final adjustment of the main reach rod should be made after boiler has reached its maximum working pressure.



TYPE OF GEAR	A	B	C	D
STANDARD	18 7/8"	12 7/8"	6"	20 1/4"
LONG LAP	25 3/16"	16 9/16"	9"	25 3/4"
LONG TRAVEL	23 19/32"	16 3/16"	7 5/8"	24 3/4"

FIG. 11

Checking Cut-Off. After the leads have been equalized the Cut-Off should be measured in at least one position of the reverse lever, usually running position in forward motion. On passenger engines it is customary to measure it at 25% cut-off position and on freight engines at 33%.

VALVE MOTION REPORT

Having completed the valve setting, it is often desired to fill out a permanent record. The form used by The Pilliod Company for this purpose is shown in Figure 13. Reports of this kind should accurately represent the actual condition of the engine, as a faulty or inaccurate report is not a valuable record.

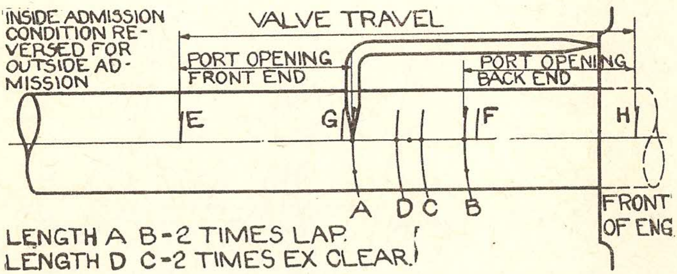


FIG. 12

To fill out the valve motion report, it is necessary to use not only the customary port marks but also the exhaust port marks, description on Page 22 tells how to obtain these. The port marks are represented by lines A and B, the distance between them being equal to two times the lap. (See Figure 12). Lines C and D represent the exhaust port marks, the distance between these being equal to two times the exhaust clearance; having obtained the port marks and the valve setting completed, the valve setter is ready to start filling out the valve motion report. To make this as clear as possible, space will be taken here to outline the operation through one revolution of the wheel.

Form 53

THE PILLIOD COMPANY
SWANTON OHIO

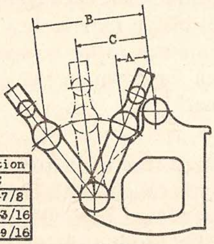
VALVE MOTION REPORT **BAKER VALVE GEAR**

Road	Gears Applied At	Type of Admission ....
Engine No.	Valves Set, date	Valve Diam. 14"
R.R.Class	Builders Name	Valve Travel 6-3/4"
Type	Builders Serial No.	Steam Lap 1-1/8"
Driver Diam.	Builders Order No.	Lead 1/8"
Cylinders	Builders Shop No.	Exhaust 1/8"
Type of Gear	TPCO Gear No.	Crank Circle ....
Type of Reverse	Type of Valve	Length of Crank ....

Reverse Yoke Positions A – B			Cut-Off Per.Ct	Cut-Off Front	Cut-Off Back	Release Front	Release Back	Comp. or Closure Front	Comp. or Closure Back	Preadmission Front	Preadmission Back	Lead Front	Lead Back	Port Opening Front	Port Opening Back
	FORWARD MOTION	Right	25												
			33												
			50												
			66												
			Full Gear	26 1/2	26 5/8	28 1/2	28 5/8	1 1/4	1 1/8	1/32	1/64	1/8	1/8	2"	2 1/2
		Left	25												
			33												
			50												
			66												
			Full Gear												
	BACKWARD MOTION	Right	25												
			33												
			50												
			Full Gear												
		Left	25												
			33												
			50												
			Full Gear												

Report First Engine Complete – Others at Running Cut-off.

One Copy to N.Y.Office and Mech.Engr. Office
One Copy to Chicago Office



Mid-Gear Position	
Type Gear	C
Standard	12-7/8
Long Travel	16-3/16
Long Lap	16-9/16

VALVES SET BY ____________

FIG. 13

Place the reverse lever in full forward motion and assume that the engine has just passed the front dead center. As the wheels are turned forward the valve will move forward until the point of maximum port opening is reached. When the valve comes to a dead stop (the wheels continuing to turn) mark the valve stem lightly with tram, as at E. (mark lightly as different cut-offs requires new marks). Then the valve begins to close the port and the wheel is stopped when the tram drops into the line "A". The valve has now closed the front cylinder port, or, according to definitions, it is in the position of Cut-Off on the front end. The piston travel is now measured from the extreme front travel mark and found to be 26½". Set this figure down on the valve motion report on line full gear right, in "Cut-Off front" column. (See Figure 13).

The wheels are again turned forward until the tram drops into the line "D". The valve is now opening the exhaust port on the front end, or according to the definition, is in the position of release. The amount of piston travel is again measured from the extreme front travel mark and found to be 28½". This figure is set down in the right full gear "release front" column. The wheels are again turned forward until the tram drops into the line "C". The valve has just closed the exhaust port on the rear end, or, is in the position of Compression. Compression is measured by the amount of unfinished piston movement. Therefore, the piston travel is measured from the other or back end of the stroke and this distance is found to be 1⅛". In other words, the steam trapped in the cylinder will be compressed for the remaining 1⅛" of the piston stroke. This figure (1⅛") is set down under "compression back". The wheels are again turned forward until the valve tram drops into the line "B". The valve is now beginning to open the steam port or is in the position of Pre-admission. Pre-admission (like compression) is measured by the amount of unfinished piston movement. Therefore, this distance is measured in the same manner as for compression, and is found to be $\frac{1}{64}$". This figure is then set down on the same line as before in the column "pre-admission back".

The wheels are again turned forward, the main pin approaching the back dead center. The dead center is caught with the wheel tram and the valve stem is marked the amount of lead, as at "F". The wheels are again turned forward and during this turning the maximum back port opening at "H" is obtained, as described above for "E". Continue turning the wheel until the tram drops into the line "B". The direction of the valve movement is now reversed or opposite to what it was when previously stopped in this position. Instead of opening the back steam port, the valve is now closing it. The engine is therefore in the position of Cut-Off back end, and on measuring from the extreme back piston travel mark is found to be $26\frac{5}{8}''$. This figure is set down on the report (on the same line as used heretofore) in the column "Cut-Off back end."

The wheels are again turned forward until the tram drops into the line "C". Remembering that the direction of the valve movement is now reversed or opposite to what it was when previously stopped in this position, it will be clearly seen that the valve is now beginning to open the back exhaust port, and is therefore in the position of Release instead of Compression, as was the case when stopped at this point while moving the opposite way. On measuring this event, from the extreme back piston travel mark, it is found to be $28\frac{5}{8}''$, and this figure is set down (on the same line as heretofore) in the column "release back end".

The wheels are again turned forward until the tram drops into the line "D". This is Compression front end and is measured by the amount of unfinished piston movement, which is found to be $1\frac{1}{4}''$. This figure is set down (on the same line) in the column "compression front end".

The wheels are again turned forward until the tram drops exactly into the line "A". This is Pre-admission front end and the valve setter finds it to be $\frac{1}{32}''$. This figure is set down (on the same line) in column "pre-admission front".

The engine is approaching the front dead center and this dead center is caught with the wheel tram and the valve stem is marked to show the lead, as at "G". This completes the readings on this side of the engine for this reverse lever position; there remaining only the measuring of the Lead and maximum port openings, and the placing of these dimensions on the valve motion report under the correct headings. The Leads are measured as follows: Front end the distance from lines "A" to "G", and the back end from lines "B" to "F". Port openings are measured as follows: Front end the distance from lines "A" to "E", and the back end from lines "B" to "H". Valve travel is measured from lines "E" to "H", or the sum of the port openings plus twice the lap, and is only measured in full gear positions. These operations are repeated in as many positions of the reverse lever as called for by the valve motion report.

Care must be taken in stopping the engine so that the tram drops exactly into the lines or otherwise errors will creep in that cause the report to show conditions which do not exist.

It will be noted that the valve motion report calls for the different events to be taken at the different percentages of cut-off. Figure 14 shows the inch equivalents for various percentages of strokes.

An easy way of placing the reverse lever accurately for the different percentages of cut-offs is as follows: Assuming that a cut-off of 7½" is desired. Turn the wheel until the piston has moved 7½" from the extreme travel mark. Move the reverse lever toward the corner until all the possible slack has been taken up. Then move it toward the center until the tram drops exactly into the line corresponding to the cut-off on whatever end of the cylinder the dimension is being taken. Use the nearest reverse lever notch and proceed to get the different events. It is not essential that the percentages called for on the report be obtained exactly as that might mean that the reverse lever would have to be blocked between notches, and that is not necessary.

INCH EQUIVALENTS FOR VARIOUS PERCENTAGES OF STROKE

Stroke	26-In.	28-In.	29-In.	30-In.	32-In.	34-In.
20%	5 3/16"	5⅝"	5 13/16"	6"	6⅜"	6 13/16"
25%	6½"	7"	7¼"	7½"	8"	8½"
33%	8 9/16"	9¼"	9 9/16"	10"	10 9/16"	11¼"
40%	10⅜"	11 3/16"	11⅝"	12"	12¾"	13⅝"
50%	13"	14"	14½"	15"	16"	17"
60%	15⅝"	16¾"	17⅜"	18"	19 3/16"	20⅜"
66%	17⅛"	18½"	19⅛"	19 13/16"	21⅛"	22 7/16"
75%	19½"	21"	21¾"	22½"	24"	25½"
80%	20 13/16"	22⅜"	23 3/16"	24"	25⅝"	27 3/16"
81%	21 1/16"	22 11/16"	23½"	24 5/16"	25 15/16"	27 9/16"
82%	21 5/16"	23"	23¾"	24⅝"	26¼"	27⅞"
83%	21 9/16"	23¼"	24 1/16"	24⅞"	26 9/16"	28¼"
84%	21⅞"	23½"	24⅜"	25 3/16"	26⅞"	28 9/16"
85%	22⅛"	23 13/16"	24⅝"	25½"	27 3/16"	28 15/16"
86%	22⅜"	24 1/16"	24 15/16"	25 13/16"	27½"	29¼"
87%	22⅝"	24⅜"	25¼"	26⅛"	27⅞"	29 9/16"
88%	22⅞"	24⅝"	25½"	26⅜"	28 3/16"	29 15/16"
89%	23⅛"	24 15/16"	25 13/16"	26 11/16"	28½"	30¼"
90%	23⅜"	25 3/16"	26⅛"	27"	28 13/16"	30⅝"

FIG. 14

TRAILING

Valve Setting without taking the dead centers is commonly called "Trailing" because it is usually accomplished by moving the engine with another one or with its own steam; however, the first method is preferred as it is rather difficult to move an engine slowly enough with its own power in short cut-off to take the port openings accurately. Only the eccentric rods, valve rods, or reach rods should be altered when this method is employed to adjust the valve.

Object to be Accomplished. It is of course impossible to accurately measure the lead without taking the dead centers; therefore, the object sought in this method of valve setting is to make the valves open the steam ports an equal amount on front and back ends on both sides of the engine and in both motions.

When Correct. Experience has shown that if the port openings at about 33% cut-off are made equal, the engine may, for this type of valve setting, be considered correct. (**Do not square port openings in full gear**).

Method Used. The reverse yoke should be set to produce about 33% cut-off in forward motion and the port openings taken, then it should be placed at about the same cut-off in backward motion and the port openings taken again. The yoke position for this cut-off varies somewhat due to the different valve settings but the following table shows the approximate positions to produce 33% cut-off and may be used as a guide. These dimensions represent the distance the center of the radius bar bearing in reverse yoke is from center of bell crank fulcrum pin.

Type Gear	Reverse Yoke Forward Motion	Reverse Yoke Backward Motion
Standard	11″	15″
Long Lap	$14\frac{3}{8}$″	19″
Long Travel	$14\frac{3}{8}$″	18″

Another way is to set the reverse lever to produce an average port opening of about $\frac{7}{16}$″. The engine should be moved one complete turn in each direction and the valve stem scribed to show the extreme movement of the valve. Particular care must be taken to see that the valve travel is the same on each side of the locomotive and the maximum travel of valve is correct. Do not mark the valve stem until all the slack has been absorbed and the reverse lever is in the correct position.

Valve Rod and Eccentric Rod Changes. The manner of calculating the changes is the same as when the lead dimensions are available, but on account of the different reverse yoke positions, the ratio of the eccentric rod change to the valve movement is also different. This ratio is 12:1 for all three types of gears, provided the reverse yokes are set as described in the foregoing paragraph.

Example 1

Front Port Marks		Back Port Marks	
40	Forward Motion	16	Front of Engine
32	Backward Motion	24	

As 40	And 16	Then 72
+32	+24	—40
72	40	32

$32 \div 4 = 8$ or $\frac{8}{64}$ or $\frac{1}{8}''$ Valve Rod Change in Direction to Correct the Controlling Error.

The effect of shortening the valve rod $\frac{1}{8}''$ would be to make the example read:

Front Port Marks		Back Port Marks	
32	Forward Motion	24	Front of Engine
24	Backward Motion	32	

Eccentric Rod Adjustment. To make this reading correct the valve should be moved $\frac{1}{16}''$ in one direction in forward motion and the same amount in opposite direction in back motion, or the eccentric rod should be shortened $12 \times \frac{1}{16}''$ or $\frac{3}{4}''$.

Rule. In inside admission gear the eccentric rod is altered in the direction the valve should move to correct the forward motion. In outside admission the change is just the opposite. This will make example read:

Front Port Marks		Back Port Marks	
28	Forward Motion	28	Front of Engine
28	Backward Motion	28	

Example No. 2—Note: This example shows the valve setting correct in forward motion but badly out in backward motion.

Front Port Marks		Back Port Marks	
28	Forward Motion	28	Front of Engine
12	Backward Motion	44	

VALVE ROD ADJUSTMENTS

As 28	And 28	Then 72
+12	+44	—40
40	72	32

32÷4=8 or 8/64 or 1/8″ Valve Rod Change in Direction to correct the controlling error.

The effect of lengthening the valve rod 1/8″ would be to make the example read:

Front Port Marks		Back Port Marks	
36	Forward Motion	20	Front of Engine
20	Backward Motion	36	

The forward motion has been distorted but if the eccentric rod is shortened 1½″ (1/8″ x 12″) this will correct all the dimensions to 7/16″.

Example No. 3 Note that in this example the engine is shown as being so badly out of square that it fails by $\frac{1}{8}''$ to open front port in forward motion. The travel is also greater in back motion than in forward motion.

Front Port Marks		Back Port Marks	
8	Forward Motion	48	Front of Engine
16	Backward Motion	40	

Here it is necessary to subtract on the front end to find the actual total opening. The port is open $\frac{1}{4}''$ in back motion and fails to open by $\frac{1}{8}''$ in forward motion. Therefore, the actual port opening on front end is $\frac{1}{8}''$ or $\frac{1}{4}'' - \frac{1}{8}'' = \frac{1}{8}''$.

As		And		Then	
	—8		48		88
	16		40		—8
	8		88		80

$80 \div 4 = 20$ or $\frac{20}{64}$ or $\frac{5}{16}''$ Valve Rod Change in direction to correct the controlling error. In this case the valve rod should be lengthened.

The effect of lengthening the valve rod $\frac{5}{16}''$ would make the example read:

Front Port Marks		Back Port Marks	
12	Forward Motion	28	Front of Engine
36	Backward Motion	20	

If the eccentric rod is lengthened ($\frac{1}{8}''$ x 12 or $1\frac{1}{2}''$) this would correct the reading to—

Front Port Marks		Back Port Marks	
20	Forward Motion	20	Front of Engine
28	Backward Motion	28	

Rules. The port opening should be squared at about 33% cut-off and not in full gear position.

Make valve rod change first; always in direction to correct greatest error.

Eccentric rod change in the direction valve should move to correct the forward motion on inside admission gears; and on outside admission gears this change is just the opposite.

It is recommended that the valve setter keep a record of each engine adjusted in this manner, showing the condition of the engine as he left it. This will be of assistance in correcting any errors in calculation.

Reach Rods. If too great a difference is found between the full gear travel of the valve on one side of the engine in forward motion, as compared to the other side, the gear reach rod may be lengthened on the side of short travel to make it equal. It should not be changed over ¼″ as this would distort the travel too much in the running cut-off. If too much change is required to equalize the travels on both sides of the engine, the eccentric crank throw should be checked.

BREAKDOWNS

General Practice. In case of failure of any of the valve gear parts (except in the reversing mechanism) take down the broken parts, secure all other parts that might swing and do damage, cover the ports and proceed on one side.

Reversing Mechanism Failures. In case of failure of any part of the reverse rigging, the reverse yokes should be blocked at the desired position and fastened securely; broken parts removed or fastened; proceed, using steam on both sides. This method includes failure of reverse lever, power reverse gear, main reach rods, gear reach rods and reverse shaft arms.

The Pilliod Company has issued an Emergency Book covering instructions in case of failures with locomotives equipped with Baker Locomotive Valve Gear, which may be obtained upon request.

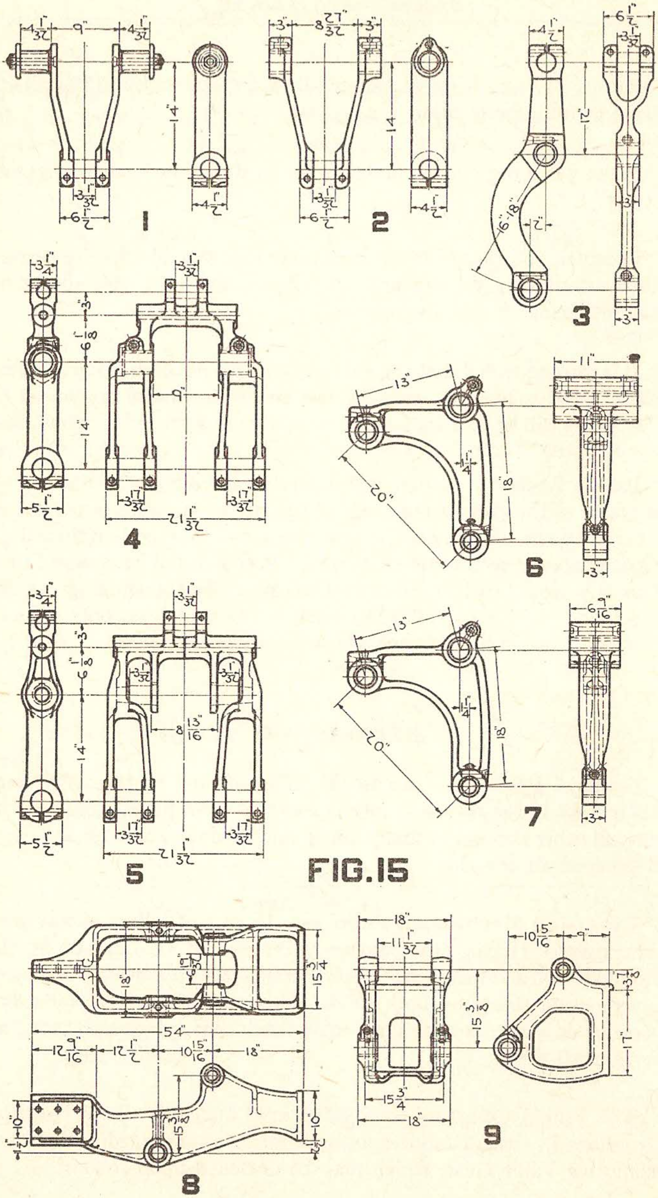


FIG. 15

VALVE GEAR PARTS

Figure 15 illustrates Baker Standard Gear parts; Figure 16, Baker Long Lap Gear parts; and Figure 17, Long Travel Gear parts.

1. Radius Bar—old style
2. Radius Bar—center hung
3. Gear Connecting Rod
4. Reverse Yoke—old style
5. Reverse Yoke—center hung
6. Bell Crank—long hub
7. Bell Crank—short hub
8. Gear Frame—long
9. Gear Frame—triangular

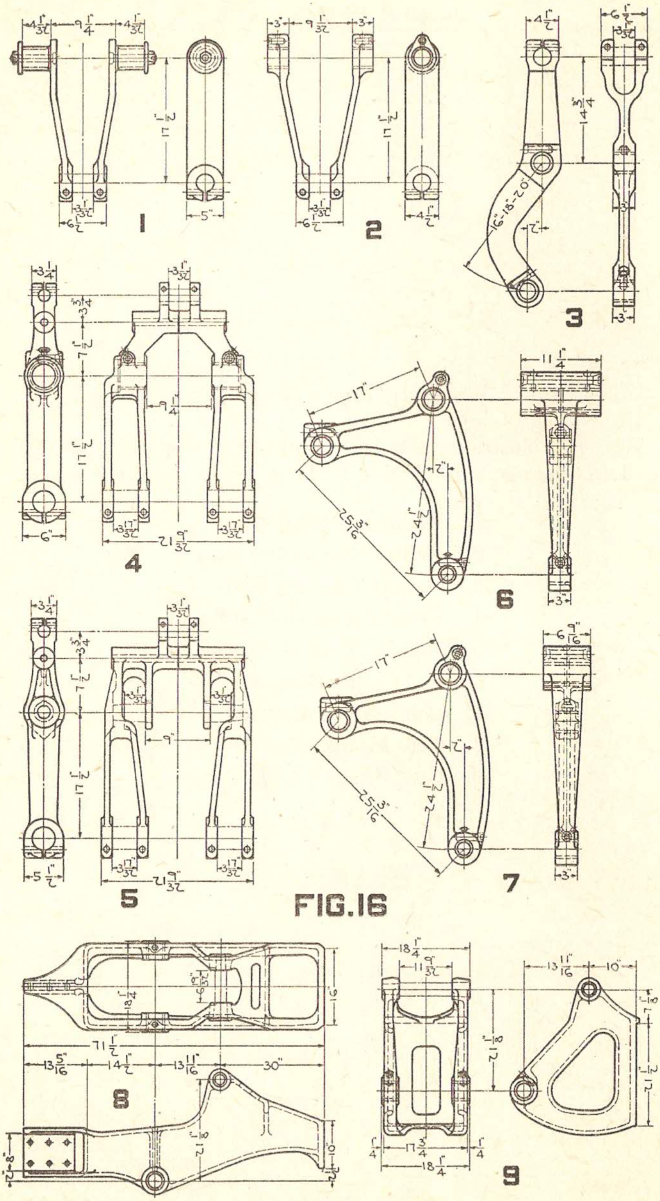


FIG. 16

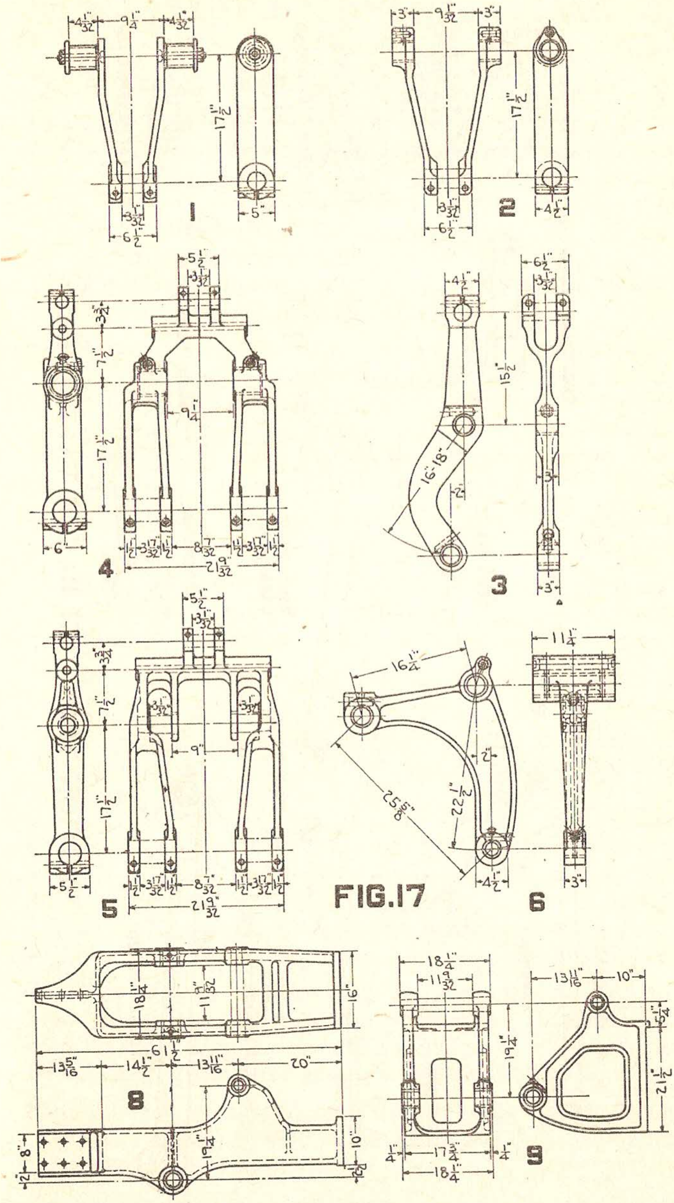
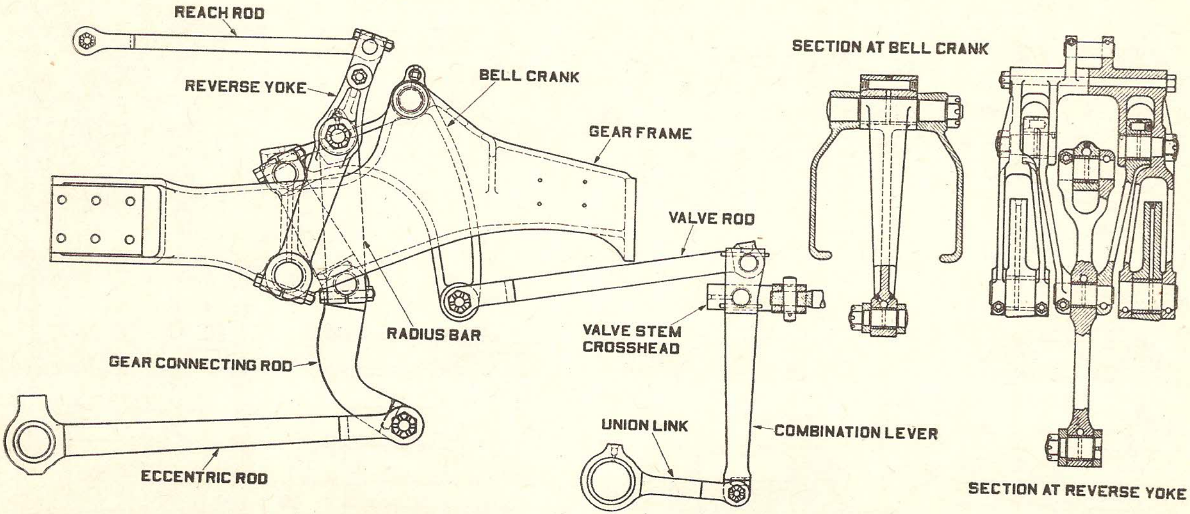


FIG. 17



SECTION THROUGH BAKER VALVE GEAR

VALVE GEAR NEEDLE BEARINGS

During the last few years a large number of needle bearings have been applied to locomotive valve gears. Two types of bearings have been used. One having a series of small rollers or needles running between an inner and outer race, which are held in place by heavy snap rings on each end of the bearing. This type of bearing is a self-contained unit which cannot come apart while the valve gear parts are either being assembled or dismantled. It is completely enclosed so there is very little danger of dirt or foreign substance getting in.

Another type of needle bearing is used where the space is limited, which has the rollers running directly on a case hardened pin. This bearing is only applied where it is impossible to use one with both inner and outer races, or in existing parts to reduce the initial cost. We recommend the use of a bearing having an inner race in preference to this type, because it will give more satisfactory service.

Figure 18 shows a cross section through reverse yoke, radius bar and gear connecting rod of a typical needle bearing application.

Figure 19 shows two different styles of application in valve stem crosshead. One has bearing with inner race in the lever, while the other has bearings without inner race in the crosshead.

Figure 20 illustrates needle bearing applied in front end of eccentric rod, union link or rear end of valve rod.

Needle bearings require less lubrication than plain bearings; in fact, too much grease is a detriment to the bearing as it locks the needles in place, thus preventing them from moving freely. Under ordinary conditions they will run from 1500 to 2500 miles between lubricating periods. The lubricant should be a high quality mineral grease or oil. It should contain no free acid or other corrosive agent and should be free from any form of abrasive matter. A light grade of ball or roller bearing grease makes a satisfactory lubricant; a heavy grease causes the needles to stick in one place and should be avoided.

When applying the bearings it is very important to have the proper fit between the outer race and the housing. They should be applied with a light driving or press fit and the pin should enter inner race freely; if it is driven in the bearing is liable to be damaged.

Parts containing needle bearings should not be cleaned in any acid solution as it is impossible to wash this out, thus causing the polished surfaces to become pitted.

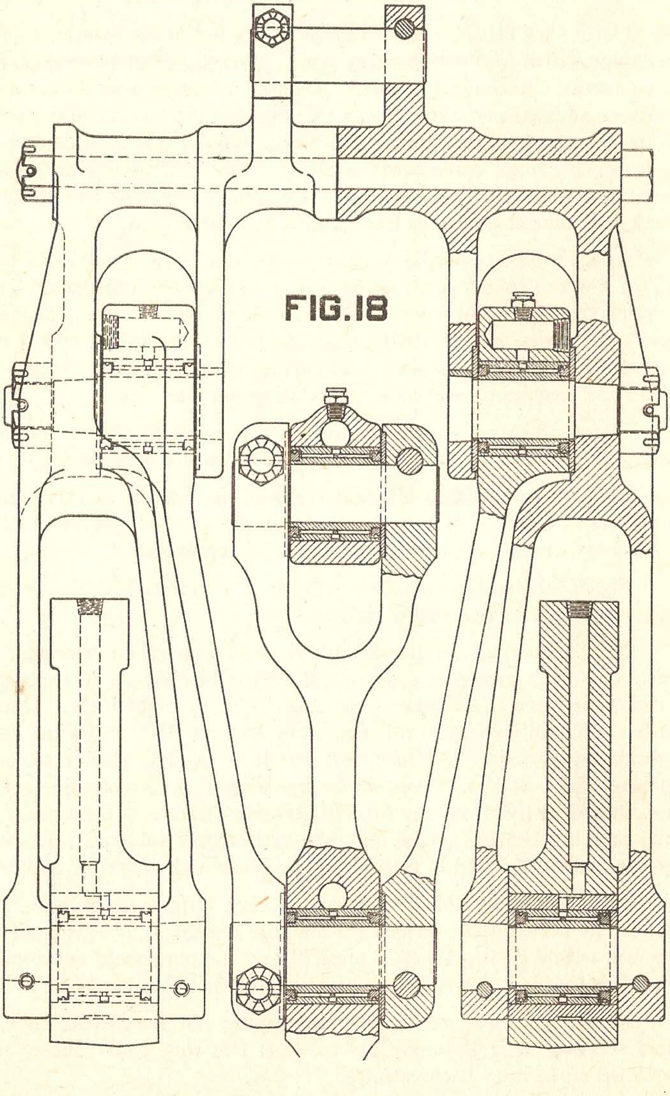


FIG. 18

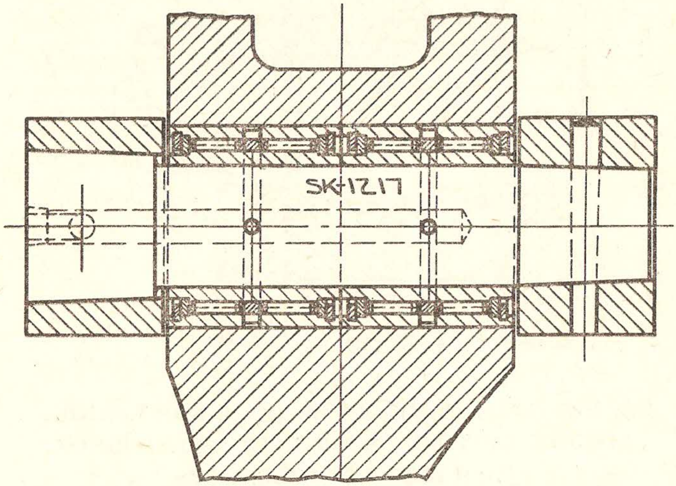
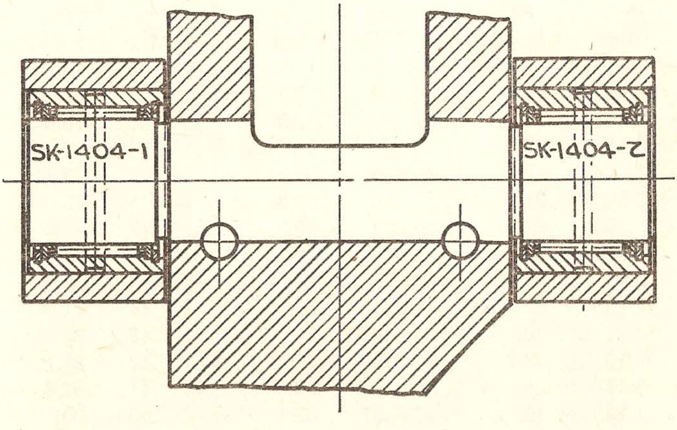


FIG. 19



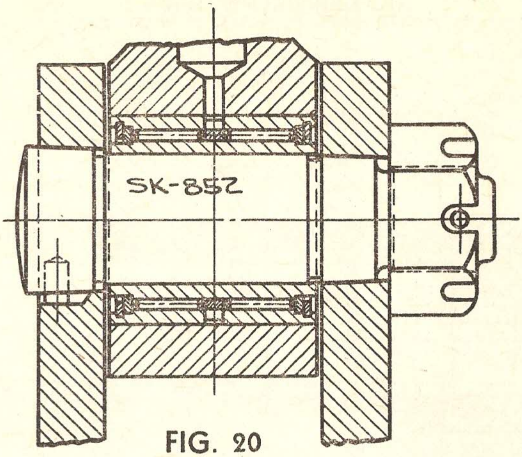


FIG. 20

TRAIN SPEEDS IN MILES PER HOUR FOR VARIOUS PERIODS OF TIME IN MINUTES AND SECONDS USED BETWEEN MILE POSTS

Time Per Mile	Miles Per Hour	Time Per Mile	Miles Per Hour	Time Per Mile	Miles Per Hour
12.	5.	1.9	52.1	.52	69.2
6.	10.	1.8	52.9	.51	70.6
4.	15.	1.7	53.7	.50	72.
3.	20.	1.6	54.5	.49	73.4
2.50	21.2	1.5	55.3	.48	75.
2.40	22.5	1.4	56.2	.47	76.6
2.30	24.	1.3	57.1	.46	78.2
2.20	25.7	1.2	58.	.45	80.
2.10	27.7	1.1	59.	.44	81.8
2.	30.	.60	60.	.43	83.7
1.50	32.7	.59	61.	.42	85.7
1.40	36.	.58	62.	.41	87.8
1.30	40.	.57	63.1	.40	90.
1.25	42.3	.56	64.2	.39	92.3
1.20	45.	.55	65.4	.38	94.7
1.15	48.	.54	66.6	.37	97.3
1.10	51.4	.53	67.9	.36	100.

WHEEL REVOLUTIONS PER MILE, AND PER MINUTE AT ONE MILE PER HOUR

Diam. in Inches	Circumference in Feet	Revolutions per Mile	Revolutions per Minute
50	13.090	403.36	6.722
51	13.351	395.47	6.591
52	13.613	387.86	6.464
53	13.875	380.54	6.342
54	14.137	373.48	6.224
55	14.399	366.69	6.111
56	14.660	360.16	6.002
57	14.922	353.83	5.897
58	15.192	347.55	5.792
59	15.446	341.83	5.697
60	15.708	336.13	5.602
61	15.969	330.64	5.510
62	16.231	325.30	5.421
63	16.493	320.13	5.335
64	16.755	315.12	5.252
65	17.017	310.27	5.171
66	17.278	305.59	5.093
67	17.540	301.02	5.017
68	17.802	296.59	4.943
69	18.064	292.29	4.871
70	18.325	288.13	4.802
71	18.587	284.06	4.734
72	18.849	280.12	4.668
73	19.111	276.28	4.604
74	19.373	272.54	4.542
75	19.635	268.90	4.481
76	19.896	265.37	4.423
77	20.158	261.93	4.365
78	20.420	258.57	4.309
79	20.682	255.29	4.254
80	20.944	252.10	4.201
81	21.205	248.99	4.149

THE PILLIOD COMPANY

Will be glad to co-operate with anyone requiring additional information concerning

"THE BAKER VALVE GEAR"

We are ready at all times to prepare designs for valve gear applications to any and all classes of locomotives. Our service Department is equipped to render co-operation at any time on any particular proposition.

All requests should be addressed to our nearest office.

THE PILLIOD COMPANY

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