THESIS

DESIGN OF APPARATUS FOR THE STANDARDIZATION OF INDICATOR SPRINGS

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DESIGN OF APPARATUS FOR THE STANDARDIZATION -: OF :- INDICATOR SPRINGS.

It is the purpose of this work to give the details of construction of an apparatus adequate to detect very minute errors in the pencil movement of indicators, relative to pressures upon the indicator piston.

The degree of accuracy which the apparatus attains depends largely upon the fineness of the workmanship and the dilegence and carefulness with which the operator perfprms his work.

The indicator is not so precise an instrument as many people suppose it to be. It is impossible to construct an indicator whose pencil point will successively travel over equal distances for the addition of equal increments of pressure upon the piston of the indicator. Nevertheless, if this variation can be determined in amount, correct readings can be obtained and consequently the usefulness and reliability of the instrument is not at all impaired.

The following is a design of an apparatus calculated to detect the error of pencil movement.

Though the details of the apparatus are considerably the work of the writer in design, yet its working principle are essentially the same as the apparatus designed by W. D. Weaver, Ass't. Eng., U. S. N.

The experiment is to be conducted with the pressures indirectly furnished by steam in order to obtain the exact conditions, und er which the indicator springs are subjected in actual practice.

For convenience of manipulation the more important parts, namely: the manifold, gauges, regulating valves etc. are mounted on a solid stand or table, as shown in Fig. I, Plate I.

The mainfold, or steam reservoir is a wrought iron tube three inches in diameter and four feet long. The ends are fitted by caps, and the whole pipe with various openings for the insertion of indicators, steam gauges, steam pipes etc., is supported by four legs which are fastened to the

table.

Provision is made for the setting of three indicators, only one being shown in the figure to avoid confusion of parts.

Referring to Fig. I, Plate I,- J. is a steam gauge whose readings are taken only to aid in regulating the admission of steam through the valve V.

The valve V. operated by the lever arm H, is a throttling valve and is designed so as to easily regulate the flow of steam.

I, is an indicator in position. The indicator cocks are supplied with grooved wheels around which a tense cord S passes. The cord is passed over grooved wheels at each end of the table and is quite heavily weighted at the ends by the weights G.

The lever arm attached to the grooved wheel t, is the means of regulating the admission of steam to the indicators.

The pressure which it is necessary for the operator

to know accurately is furnished by the mercury column shown in figure 4. This column is composed of a metal tube, with an accompanying scale graduated to increments of five pounds-- the usual intervals for the testing of springs. At every five pound mark insulated points are inserted so that when the mercury has risen to any desired height an electrical circuit is closed by contact of the insulated point and the mercury column. This circuit by passing through an armature is the means of setting in motion the automatic mechanism for operating the pencil and drum movements.

The steam is allowed to play upon the mercury in the mercury reservoir R, Fig. 4 , by being admitted through the pipe E. Near the cutting off of this pipe at E, but not shown in the figure, is a check valve whose duty it is to allow the admission of steam only when the pressure on the back side of the valve has attained the desired height.

AT S, (Fig. 4) is a regulating screw which operates a plunger Q. Accompanying this screw is a dial over which

an index finger, attached to S, passes. By turning the screw S, a certain part of a revolution or more, which the dial will indicate, the height of the mercury will be raised by the plunger being forced into the mercury reservoir. The dial is graduated to the increments of five pounds and so adjusted that when the screw at S is turned to the notch indicating the addition of five pounds the mercury column will rise to within 1/8 inch of the corresponding insulated point. This places the pressure on the mercury side of the check valve and thus the steam acts on the mercury for only a short time, and then only on a very small section in the pipe E. The comparatively large area in the reservoir compared to the area in the mercury column eliminates any appreciable error in the pressure when the steam is admitted to raise the column that last 1/8 inch.

As I have before said, the steam acts on the mercury for a very short time, and then only on a small area; but for any liability of error creeping into the results by inconstant temperature of mercury, a thermometer is pro-

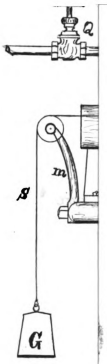
vided which is read at every time steam is admitted, and its corresponding correction added to the results of the experiments.

To further aid in maintaining a constant temperature, a jacket M is furnished for the reservoir through which running water is continually circulating. The pipe E, is the continuation of the pipe F in Fig. I.

Passing now to the mechanism for operating the pencil and the drum movement of the indicators, we find the apparatus working the drum to be shown by the shaft K with its attachments in Fig. I. This shaft is mounted upon the table and supported at each end by two standards shown at Y.

Though not clearly shown in the drawing, it can be seen that each indicator has on this shaft a circular arc L, to which the string of the indicator drum is attached.

Arrangement is made to operate this drum movement by a pedal attached to the shaft by a system of lever arms. Stop bolts K in the frame B of table permit of a certain


Q
m
A
G

amplitude in swing of the arc L. The weight W on the lever arm V', is designed to aid the drum spring in its retroactive movement. The drum movement is, however, usually operated automatically by electric circuit through the mercury column. Where this is done the system of levers is disjointed at U.

The shaft for working the pencil, on account of avoiding confusion in the drawings, is not shown in Fig. I, Plate I, but is shown in Fig. 2,Plate II. at k.

The position of this shaft is between the manifold and the shaft for operating the drum movement.

The necessity for a pencil movement apparatus lies in the demand to eliminate unnecessary friction of the pencil point on the paper.

The function of the pencil movement apparatus is to keep the pencil point off the paper until the desired height of the mercury column, and hence the desired position of pencil point for tracing the line,is arrived at. When this height of mercury column has been obtained the

pencil point is automatically allowed to press lightly against the paper. The accomplishment$ of this operation is as follows:

When everything is in readiness, the lever arm R (Fig. I, Plate I) is drawn back until another arm E catches hold of the notch in the aramture beam F, (Fig. I, Plate I) The drum shaft, which in figure 2 Plate II. corresponds to E, is supplied with an arm F which trips on anpther arm L' on the pencil movement shaft. This movement causes the arm L' to occupy the position indicated by the dotted lines where it is held by the detent shown by the parts C and P. The rod A, (Figs. 2 and 3, Plate II.) operates to hold the pencil away from the drum.

Now, again referring to the drum motion, and more particularly to its motion as controlled by the electric current. It is to be understood that when the circuit is closed by the mercury column coming in contact with the insulated point, the armature beam F, Fig. 1 is attracted, thus releasing the lever arm E. As scon as the armature beam is attracted its rear end H (which is attached to the

detent on the pencil movement shaft by the member D, Fig. 2 Plate II.) acts upon the detent so as to make the pencil point press lightly on the paper. The detent is operated shortly before the drum shaft is set in motion, and as the pencil point is held at a very small distance from the paper, the pencil point touches the paper in time for the motion of the drum. The pressure of the pencil point is brought about by a small spring shown at B, (Fig. 3, Plate II.)

The next time the lever arm R is actuated for the taking of a second reading the succeeding graduated point on the mercury column scale is put so it will be in circuit next by an arrangement shown in Fig. I, Plate II.

M. is a standard mounted on the table. The drum shaft indicated at D passes through this standard and when rotated it causes the annular ring B, carrying an arm A, to slide in the standard by means of the dog C. The arm A passes successively over insulated points arranged in a circle and set in the face of the standard M. So each time the drum shaft lever is moved the arm A takes a new posi-

tion over the succeeding insulated point. When the circuit is closed and the drum shaft released the dog slides back to get another hold.

It is found necessary to take readings with the down friction of the piston movement as well as with the up friction movement. To make the armature work for a descending mercury column, it is found necessary to have the instrument regulated by the breaking of contact instead of the making of contact. This is accomplished by placing in the circuit another armature whose beam is held against its poles as long as the mercury is in contact with the insulated point; but as soon as contact is broken, it is released and closes the circuit to second aramture which regulates the drum shaft.

It is also necessary to take readings below the atmosphere line. These readings are taken at interavls of 2 1/2 #.

The steam gauge is removed and a plug inserted in its place. In Fig. 2, Plate I. is shown a receiver from which the air is extracted. J is a vacuum gauge and records the

difference in pressure.

At Fig. 3 is shown a mercury column to regulate the pressure .

The mercury reseservoir R is supplied with a flexible bottom which permits the zero mark being adjusted by the screw S.

A in Fig. 5 is a drip pot, to rid the air or steam coming from the manifold, of any moisture it may contain.

When everything is in readiness for a reading, the valve O, Fig. I is opened. The air or steam then passes into pipe B and the drip pot, and through pipe T the mercury column is finished. The valve V, Fig. 3, operates the passage to the vacuum chamber.

To raise the mercury in the column the valve V is opened and sufficient air admitted to the chamber to allow the mercury to rise to the 2 1/2 # mark, at which time the pedal P is touched and the line traced on the card.

In case too much air has been let out, causing the column to rise too high, more air may be admitted through

the two way cock F, in Fig. 1.

When the difference in pressure in the vacuum chamber has become too low, the vacuum pump may be started again.

A general description of the apparatus has been given.

The principal points in conducting a test are about as follows:

Allow the steam to circulate thoroughly through the apparatus to get it heated up. Get every point at which hurtful friction is liable to occur well lubricated. Of course the piston of the lubricator must be lubricated by oil being fed into the steam pipe. Every valve should be tested to see that it works properly. As soon as these items have been considered, cards are placed on the indicators,- first placing on each card its number of spring, the temperature and the statement as to whether the observation was made with the up going friction or not. The precautions are taken to avoid the mixing of the cards when they are removed.

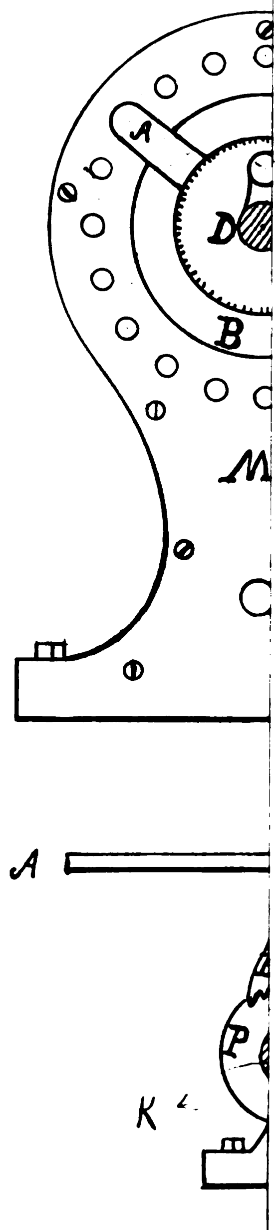


Fig.

Adjust with the screw S, Fig. 4, Plate I, the height of the mercury column to the 5# mark, seeing at the same time that the 5# mark will be in circuit, which is brought about by adjusting the lever arm R. The steam is carefully admitted through the valve V, Fig. I, the operator closely watching the steam gauges so as not to admit steam too quickly.

When the pressure has risen suffuciently, the steam will force its way through the check valve on the pipe leading to the mercury reservoir and cause the mercury to rise 1/8 inch more to the insulated point and trip the drum shaft mechanism. As soon as the line has been made the steam valve should be closed, in order that the preparations for the next reading may be made.

The drum shaft is again adjusted by taking a swing of the lever arm R.

The mercury column is readjusted, then the steam is admitted until the drum shaft trips again. When sufficient readings for a spring have been taken the cards are removed and more put in their places with their proper labels.

Cards are taken both with increasing and decreasing pressure, in order to compensate the friction of the indicator piston.

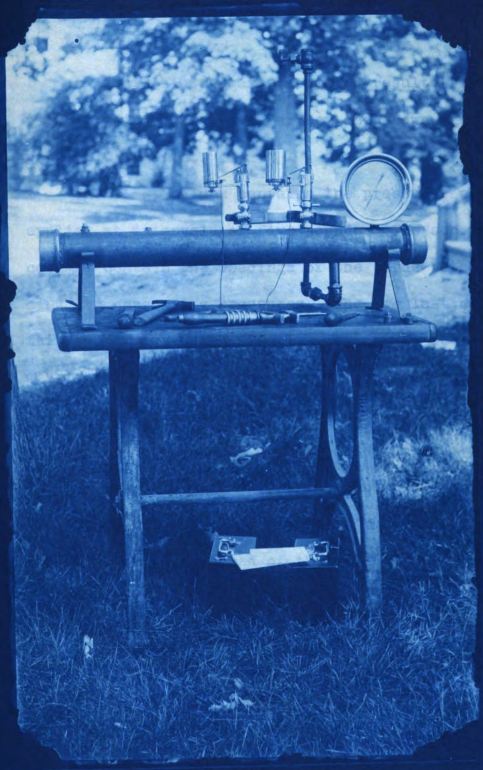
The final readings are selected at mid points of the up and down readings.

Tests made with the crude apparatus shown in the blue Print were made with a No. 20 spring from a Crosby Indicator and a comparison between the two tests made can be obtained from I'and 2, Fig. 5, Plate II.

In 3, we have what the reading should have been had the spring been accurate. When the averages of all the errors have been made they can be arranged in convenient form, as shown in Fig 4 , Plate II. Errors for each increment of pressure being determined, the error curve by a system of coordinates can be traced.

Thus, when any given spring has been used, its curve of error can be made use of in making the card deductions.

PART II. OF THESIS.



PART II. OF THESIS.

The following are tabulated results from tests made with the apparatus by the writer and shown in the accompanying blue print.

The first column contains the pressures which were applied at intervals of five pounds. The second and third columns contain the readings of the cards both for ascending and descending pressures. The two last columns contain the errors which are plus, or minus, according as the mean reading is above or brlow the corresponding pressures.

In measuring the cards, the zero points of the up and down motions are placed opposite and thus compared.

The springs used were those accompanying the two Crosby Indicators used in the apparatus, The number of the spring used appears at the head of the table.

To obtain the pressures used, which are recorded in the first column, a Crosby Test gauge was used, which was previously tested Crosby's Weight Testing Apparatus, and found to be in correct calebration.

The springs marked with a sub script (1) are from the small drum Crosby Indicator No. 842, while those marked

with a sub script (2) are from the large drum Crosby Indicator No. 1804.

SPRING NO. 20

# Pressures.	UP Friction.	DOWN. Friction.	PLUS. Errors.	MINUS. Errors.
5	6 3/4	7	1 7/8	
10	11 1/2	12	1 3/4	
15	16	16 3/4	1 3/8	
20	21	22	1 1/2	
25	26	26 3/4	1 3/8	
30	31	31 3/4	1 3/8	
35	35 1/2	36 1/2	1	
40	41	41 3/4	1 3/8	

SPRING NO. 20_2

# Pressure.	UP Friction	DOWN Friction.	PLUS Errors.	MINUS Errors.
5	8 1/2	8	3 1/4	
10	13 3/4	14	3 7/8	
15	19	18 1/2	3 3/4	
20	23 1/4	23	3 1/8	
25	28	27 1/2	2 3/4	
30	31 1/2	32	1 3/4	
35	36	36 1/2	1 1/4	
40	40 3/4	41	7/8	
45				
50				

SPRING NO. 40_1:

# Pressure.	UP. Friction.	DOWN. Friction.	PLUS. Errors.	MINUS. Errors.
5	7	7 1/2	2 1/4	
10	11 1/2	12 1/2	2	
15	17 1/4	17	2 1/8	
20	23 1/2	22	2 3/4	
25	28	26 1/4	2 1/8	
30	32	31	1 1/2	
35	38	35 3/4	1 7/8	
40	41 1/2	39	1/8	
45	46 1/2	44 1/2	1/2	
50	51	50 1/2	3/4	
55	55 1/2	55	1/4	
60	58	61	---	1/2

SPRING NO. 40$_2$

# Pressure.	UP Friction.	DOWN Friction.	PLUS Error.	MINUS. Error.
5	7 1/4	7 1/2	2 3/8	
10	11	12 1/4	1 5/8	
15	17	16 1/2	2 1/4	
20	22 1/4	21 3/4	2 1/2	
25	27 1/4	26 1/2	1 7/8	
30	31 3/4	31	1 3/8	
35	36	35 1/2	3/4	
40	39 1/2	39	-----	3/4
45	45	44 1/2	-----	1/4
50	49 1/2	49 1/2	-----	1/2
55	54	-------	-----	I
60	59	-------	-----	I

SPRING NO. 50_1

# Pressures.	UP Friction.	DOWN Friction.	PLUS Errors.	MINUS. Errors.
5	6 1/2	7	1 3/4	
10	11	11	1	
15	15 1/2	16	3/4	
20	19 3/4	20 1/2	1/8	
25	24 1/2	24		1 1/4
30	29	28		1 1/2
35	33 1/2	33		1 3/4
40	38 1/2	37		2 1/4
45	43	42		2 1/2
50	47	47 1/2		2 3/4
55	51 3/4			3 1/4
62	62 1/2	62	1/4	
60	57			3

SPRING NO. 60_1.

# Pressures.	UP FRICTION.	DOWN FRICTION.	PLUS ERRORS.	MINUS. ERRORS.
5	7	7 1/2	2 1/4	
10	11	11 1/2	1 1/4	
15	16 3/4	17	1 7/8	
20	22	22	2	
25	26 1/4	26 1/2	1 3/8	
30	30	31	1/2	
35	35 1/4	36	5/8	
40	39 1/2	40 1/2	-----	
45	44	45		1/2
50	48	49		1 1/2
55	52	53 1/2		2 3/4
60	56	58 1/2		2 3/4

SPRING NO. 60_2.

# Pressures.	UP Friction.	DOWN Friction.	PLUS Errors.	MINUS. Errors.
5	6 1/2	6 1/2	1 1/2	
10	11 1/2	12	1 3/4	
15	16 1/2	16 3/4	1 5/8	
20	21	22	1 1/2	
25	25 1/2	25	3/4	
30	30	29		1/2
35	34	35 1/2		1/4
40	38 1/2	40		3/4
45	44	46	------	---
50	50	50 1/2	1/4	
55	55 1/2	56	3/4	
60	60 1/2	60 1/2	1/2	
65	66 1/2	66	1 1/4	
70	70 1/2	70	1/4	
75	74 1/2	75 1/2	-----	---
80	79 1/2	81	1/4	
85	84	86	-----	---
90	89	92	1/2	
95	94 1/2	96	1/4	
100	98 1/2	100 1/2		1/2

SPRING NO. 80.

# PRESSURES.	UP FRICTION.	DOWN FRICTION.	PLUS ERRORS.	MINUS. ERRORS.
5	6 1/2	6 1/4	1 3/8	
10	11	11 1/2	1 1/4	
15	15 3/4	15 3/4	3/4	
20	21 1/2	21 1/2	1 1/2	
25	25 1/2	25 3/4	5/8	
30	30 1/2	31	3/4	
35	36	35 3/4	7/8	
40	40 1/2	40 1/2	1/2	
45	45 1/2	46	3/4	
50	51	50 1/2	3/4	
55	55 1/2	56	3/4	
60	61 1/2	61	1 1/4	
65	65 1/2	65 3/4	5/8	
70	71	71 1/2	1 1/4	
75	75 1/2	76	3/4	
80	81	81 1/2	1 1/4	
85	86	87 1/2	1 3/4	
90	92	92 1/4	2 1/8	
95	96 1/2	97 1/2	2	
100	99 3/4	101 1/2	5/8	

Going Up

Card No 4

60
55
50
45
40
35
30
25
20
15
10
5
0

Spring 60

Going Up.

Card No

40
35
30
25
20
15
10
5
0

Spring 20

Going Down

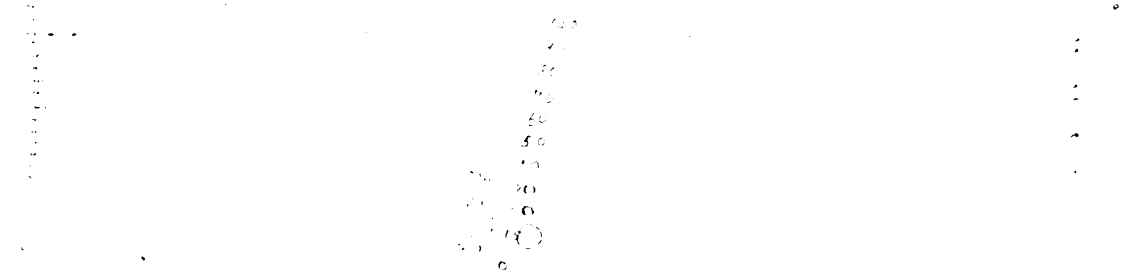
Card No 7

40
35
30
25
20
15
10
5
0

Spring 20

Spring No 50

Card No 5



Spring No 40

Card No 3

Spring No 30

Card No 7