THESIS

TESTS ON A HYDRO-PNEUMATIC PRESS

GEORGE T. BENTLEY

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TESTS ON A HYDRO-PNEUMATIC PRESS

T H E S I S

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By

GEORGE T. BENTLEY

Candidate for the degree of

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THESIS

TABLE OF CONTENTS

The author wishes to express his gratitude to the following persons and authorities for aid in conducting these tests and for information given.

MR. H. B. DIRKS, Professor of Mechanical Engineering, Michigan Agricultural College.

Mr. G. C. Wright, Foreman Machine Shop, Michigan Agricultural College.

Mr. C. A. Holdridge, Chief Engineer, Hydraulic Machine Department, Eastern Production Company, Detroit, Mich.

AUTHORITIES

Handbook for Machine Designers, Shop Men and Draftsmen
F. A. Halsey.

Elements of Machine Design
Kimball and Barr.

I

INTRODUCTION

The Eastern Production Company of Detroit, Michigan has placed in the Machine Shops of the Michigan Agricultural College, for the use of her students, a Hydro-pneumatic Press which promises to be of great use to them.

The machine was placed at this College through the kindness and good will of Mr. A. P. Corrigan, who was at one time a student at M. A. C., and is now at the head of this Company.

The Eastern Production Company is at present making hydraulic and hydro-pneumatic presses of various sizes to a large extent. They have as the Chief Engineer of the Hydraulic Machine Department, a man of some ability in the design and construction of this type of machine, Mr. C. A. Holdridge.

Mr. Holdridge's latest design is this hydro-pneumatic press, one of which is in the Machine Shop of this College today. This machine seems to be meeting with great success in many shops as a solution to problems in the quick and accurate straightening of both rough stock and machined parts, and in many other jobs for which a light press will be a saving in time and money.

Mr. Corrigan in placing this machine at the disposal of the College, wished that it be used not only as an adjunct to the Machine Shop equipment, but that it should also acquaint the student with the use of this type of machine in modern shop practice. The men who go from this college will be the managers of the near future, and if at this time the usefulness of a product can be impressed upon them, it will probably be their choice when they have a job to do for which this machine is fitted.

Such a gift is of great benefit to the College in that it is a clear proof that her Alumni are loyal, and willing to do whatever is in their power to assist their Alma Mater, and that they consider the College as a real live factor in the Business World.

PURPOSE

In casting about for a subject on which to write a thesis, Professor Dirks suggested that the author might investigate the possibilities and uses of the Hydro-pneumatic Press, which had been donated to the College by the Eastern Production Company of Detroit, Michigan.

The machine is rather an innovation along this line and its possibilities have not as yet been given a thorough and painstaking investigation.

At first owing to lack of data and knowledge about the uses of the machine, it seemed as if the variety of work which could be done along this line was very small, but after several trips to Detroit, and talks with Mr. Holdridge, the Inventor, the number of tests and the amount of data which could be made and found was so augmented that finally it was necessary to narrow the tests down to three or four things which we propose to carry out.

Since the machine is now in manufacture, the Inventor believes that several improvements can be made in its design, and in the care of its machining the first thing to do is to inspect all the machining and assembly work to see if anything could be improved here. Then to find its weak points in design and suggest their remedies.

Second, to check the design for strength, especially the G-frame of the body to see if it is made sufficiently strong to hold up under the load it has to carry.

Third, to make a study of its uses and tabulate such data as may be found useful.

The machine was primarily designed for the accurate straightening of work, such as short shafting, and it was the authors intention to give the machine an exhaustive test in this. However, due to the fact that it was impossible for the college to obtain the necessary attachment for doing this work, and as the machine is also useful as our arbor press, it was decided to test it in this capacity.

III

DESCRIPTION OF THE MACHINE

The main features of the machine are a piston and piston rod in the base actuated by compressed air. A high pressure oil well and a high pressure ram actuated by oil pressure.

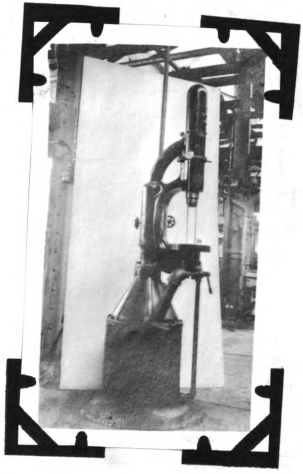
Referring to the assembly blue print accompanying this work, it will be seen that compressed air enters the intake at a pressure of between seventy-five and a hundred pounds gage, and passing through the two way valve enters the large cylinder at the base. The piston is forced upward, and the piston rod compresses the oil which fills the cylindrical well and curved channel in the body of the machine. This compressed liquid pushes down on the ram(20) with a maximum force of approximately fifteen tons depending on the pressure of the air in the base.

When the-two way valve is thrown to its opposite opening the air under the piston is released and new air rushes in on top of the piston forcing it down. The oil pressure being released, the ram returns to its highest position through the action of the coil spring(24).

The reason that such a high pressure can be attained on the ram is, that the area on which the compressed air acts is much larger than this area acting on the oil. The pressure per sq. in. of air and oil respectively are inversly proportional to the areas of the piston and piston rod.

The cup leather packing(35) makes an oil tight bearing on the ram, and the packing gland(17) makes an oil tight bearing on the piston rod. There is also an oil tight bearing in the packing gland on the ram return guide rod (23). The surface between the cylinder and cylinder cover and between the cylinder cover and the body are kept tight by means of studs holding plane surfaces between which is inserted a packing of heavy drawing paper heavily shellaced.

The machine has a round table with a hole bored in the center which gives an excellent attachment for making press fits and shrink fits. It is useful for all kinds of mandrel work, or any work in which it is necessary to press two or more pieces together with great force. The Company also manufactures a table for straightening work from six inches up to two feet in length which is very quick and accurate, it being possible to get an accuracy of two-thousandths of an inch, according to stagements made by representatives of the manufacturer. It is unfortunate that the College has no such table as some interesting work could be done on it.



IV

SUGGESTIONS FOR IMPROVEMENTS

After dissembling the machine and examining the workmanship, it was assembled and tested at a high pressure. The following are some of the faults which were brought to light, and suggestions are here made for their improvement.

1. The filling and drain plugs for oil are merely screwed into the cast steel body and if they are not carefully coated with white lead each time of removal and screwed in very tight they are pretty sure to leak oil when the pressure is high. Since it is unnecessary to remove the drain plug often, it is not thought necessary to change this construction, but there is always some oil leak making it necessary to refill the oil well, and a good sturdy filling cock is needed here.

2. The machine that is in the shop leaks some oil past the cup leather packing at the top of the ram. This in itself is not a bad fault if the oil would not fall on the operating table, so the suggestion was made to Mr. Holdridge that an oil groove be cut near the bottom of the ram cylinder, and a small pipe lead off to one side to drain the oil away from the table. However, at the time Mr. Holdridge had already made what he thought was a cheaper and better improvement. He cored out the ram cylinder leaving a bearing surface about two inches long at the bottom, and then placed a packing gland below this.

The top of the ram is to be guided by the return guide rod (27) through its packing gland (23).

3. The flange for the studs which join the body and the cylinder cover is of poor construction, and it is very difficult to tighten the studs enough to keep the drawing paper packing from blowing out. Mr. Holdridge, however, tells me that this has been improved in later machines.

4. The machine which is here in the College is put together very carelessly, and there were some cast iron chips lodged between the cup leather packing and cylinder wall at the top of the ram, which accounted for a part of the oil leak at this place. There was quite an accumulation of core sand on and about the large cylinder, which if allowed to stay there and the machine be used much would soon make a leaky piston. Mr. Holdridge was informed of these facts and took steps to get more careful assembly.

V

THEORETICAL CHECK OF THE BODY FOR STRENGTH

From the appearance of the G frame body, it was thought to be rather weak at the center, so an extensometer was put on the machine to determine the amount of strain under different loads. This extensometer is shown set up on the machine in one of the photographs. A tabulation of the strains is shown below;

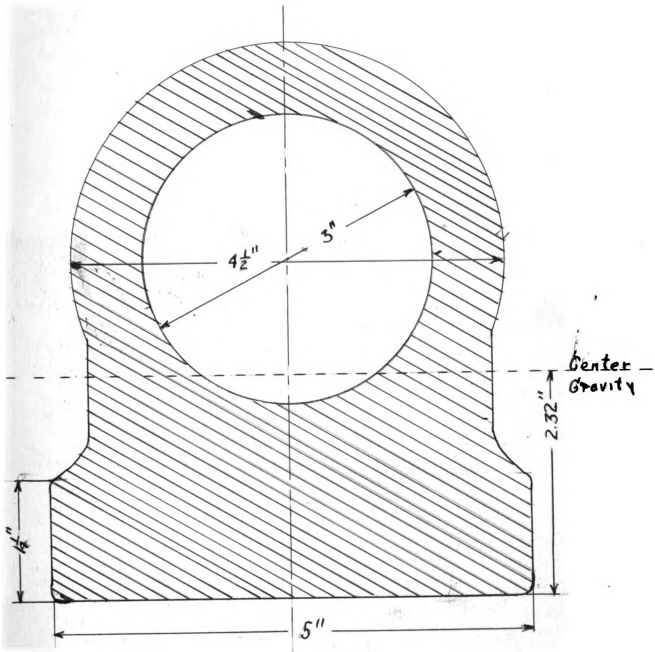
Load tons	right dial	left dial	difference right dial	difference left dial	average difference
0	23.5	25			
1	25.5	21.5	2	3.5	2.75
2	28	18	4.5	7	5.75
3	30.4	15.7	6.9	10.7	8.8
4	33.5	13.5	10.	12.	11.
5	36.2	10.2	12.7	14.8	13.75
6	40	8.	16.5	17.	16.75
7	42	5.4	18.5	19.6	19.05
8	44.8	3.	21.3	22.	21.65
9	47.	.4	23.5	24.6	24.05
10	50	-2	26.5	27.	26.75
11	52.5	-5	29.	30.	29.5
12	55.	-8.4	31.5	33.4	32.45
13	58.	-10.	34.5	35.	34.75

REMARKS: All measurements are in thousandths of an inch at the center line of the ram.

Owing to low air pressure, it was impossible to get more than a load of thirteen tons.

HORIZONTAL CROSS SECTION THROUGH THE CENTER OF THE C FRAME OF

A 10-15 TON HYDRO PNUEMATIC PRESS



From the foregoing data it appears that the structure may be too weak to take the stresses of a full load so it will be wise to check its strength. For dimensions of the section in doubt see the sketch on page 14.

Consider the frame to be in the form of a hollow circle tangent to a rectangle, the material being cast steel, then:
Area of the hollow circle a_c= 3.1416 x $(2.25)^2$ minus 3.1416 x $(1.5)^2$ a_c= 9 sq. in.
Area of rectangle a_r = 1.25 x 5
a_r= 6.25 sq. in.
Taking moments about the axis X------X to find center of gravity

$$C.\ G.= \frac{9 \times 3.5 \text{ plus } 6.25 \times 6.25}{15.25} = 2.32"$$

Taking the maximum load to be fifteen tons and the allowable fiber stress for cast steel to be 10000 lbs. in tension.
The reach of the machine is 7".

$$p= \frac{P}{A} + \frac{Pae}{I}$$

P = 30000 lbs.
A = 15.25 sq. in.
a = 7 + 2.32 = 9.32 in.
e = 2.32
I = 97.63 for this section

$$p_t= \frac{30000}{15.25} + \frac{30000 \times 9.32 \times 2.32}{97.63}$$

$$p_t= 8620 \text{ lbs/sq. in.}$$

Which is a safe load on cast steel.

Checking for compression on the back of the frame.

$$P_c = \frac{30000}{15.25} + \frac{30000 \times 9.32 \times 3.43}{97.65}$$

$$P_c = 7880 \text{ lbs/sq. in}$$

VI

TESTING OF FORCE FITS

To test the usefulness and capacity of the machine, it was found desirable to make some force fits of cast iron hubs or rings on steel shafts.

From Halsey's Handbook it was found that for reamed holes in cast iron hubs and steel shafts ground to size the machine would handle about a maximum allowance of three thousandths of an inch. The ratio of the outside diameter of the hub to the inside diameter to be three.

Following are tabulated dimensions of the rings and the shaft.

RINGS OR HUBS

No	length	outside diameter	inside diameter	material
1	2 in.	1 1/2 in.	1/2 in.	cast iron
2	" "	1 1/2 "	1/2 "	" "
3	" "	1 1/2 "	1/2 "	" "
1a	" "	3 "	15/16 in.	" "
2a	" "	3 "	15/16 "	" "
3a	" "	3 "	15/16 "	" "
4a	" "	3 "	15/15 "	" "
5a	" "	3 "	15/16 "	" "
1b	" "	4 1/2 "	1 1/2 "	" "
2b	" "	4 1/2 "	1 1/2 "	" "

SHAFTS

No.	length of ground surface	diameter of ground surface	allowance for force fit	material
1	2 in.	.501	.001	cold rolled steel
2	" "	.502	.002	" " "
3	" "	.503	.003	" " "
1a	" "	.9385	.001	" " "
2a	" "	.9395	.002	" " "
3a	" "	.9405	.003	" " "
4a	" "	.9385	.001	" " "
5a	" "	.9385	.001	" " "
1b	" "	1.501	.001	" " "
2b	" "	1.502	.002	" " "
3b	" "	1.503	.003	" " "

The shafts were made slightly longer than 2 inches and a taper of ten degrees given the end to give an entering guide

The shafts were now forced into the hubs on the hydro-pneumatic press and the pressure required noted. They were then forced out again recording the pressure required to start them out and forced in again on the Olsen Testing Machine in the Engineering Laboratory at M. A. C.

Three specimens of the same size and allowance namely; 15/16 in. diameter and .001 thousandths allowance, were forced in in different manners for purposes of comparison. No. 1a was forced in on the hydro-pneumatic press. No. 4a was pressed in on the same press, but without lubricant. No. 5a was forced in on the Olsen Testing Machine.

RECORDED PRESSURES ON 10-15 TON HYDRO-PNEUMATIC PRESS FOR FORCE FITS

No of piece	diameter	allowance	pressure to start tons	maximum pressure	lubricant
1	1/2 in.	.001	1	1.5	Machine oil
2	1/2 in.	.002	1.5	3.	" "
3	1/2 in.	.003	1.5	3.5	" "
1a	15/16 in.	.001	0.5	2.	" "
2a	15/16 in.	.002	0.75	4.	" "
3a	15/16 in.	.003	0.5	5.	" "
1b	1 1/2 in.	.001	0.5	5.	" "
2b	1 1/2 in.	.002	0.5	4.	" "
3b	1 1/2 in.	.003	1.5	4.	" "

RECORDED PRESSURES ON OLSEN TESTING MACHINE SHAFTS HAVING BEEN PREVIOUSLY FORCED IN ON THE HYDRO-PNEUMATIC PRESS AND WITHDRAWN

No of piece	diameter	allowance	pressure to start tons	maximum pressure tons	lubricant
1	1/2 in.	.001	------	0.3	machine oil
2	1/2 in.	.002	0.25	2.25	" "
3	1/2 in.	.003	0.5	1.8	" "
1a	15/16 in.	.001	0.2	1.6	" "
2a	15/16 in.	.002	0.5	2.7	" "
3a	15/16 in.	.003	0.5	3.5	" "
1b	1 1/2 in.	.001	0.6	4.5	" "
2b	1 1/2 in.	.002	0.4	2.6	" "
3b	1 1/2 in.	.003	0.5	1.6	" "

REMARKS: It will be noticed that the pressure required to force the three different allowances on the 1 1/2" rings does not increase directly as the allowance, but on the contrary decreases. It is thought that this is due to faulty reaming of the holes in that they were slightly out of round on specimens 2b and 3b.

Three specimens of the same diameter and allowance were forced in under different conditions as follows:

No of piece	diameter	allowance	pressure to start tons	maximum pressure tons	lubricant
	FIRST PRESSURE APPLIED ON HYDRO-PNEUMATIC PRESS				
1a	15/16 in.	.001	0.5	2	Machine oil
	REPRESSED ON OLSEN TESTING MACHINE				
1a	15/16 in.	.001	0.2	1.6	Machine oil
	FIRST PRESSURE APPLIED ON OLSEN TESTING MACHINE				
5a	15/16 in.	.001	0.28	2.58	Machine oil
	FIRST PRESSURE APPLIED ON THE HYDRO-PNEUMATIC MACHINE				
4a	15/16 in.	.001	0.5	12 plus	NONE NONE

N. B. The specimen was cut for lack of lubricant and it was impossible to force it home on this machine

PRESSURE NECESSARY TO START THE SHAFTS OUT ON THE HYDRO-PNEUMATIC PRESS AFTER THEY HAD BEEN LEFT IN ONE DAY.

No of piece	diameter	allowance	pressure required tons to start
1	1/2 in.	.001	0.5
2	1/2 in.	.002	4
3	1/2 in.	.003	3
1a	15/16 in.	.001	2
2a	15/16 "	.002	3
3a	15/15 "	.003	6
1b	1 1/2 "	.001	6
2b	1 1/2 "	.002	4
3b	1 1/2 "	.003	4

VII

CONCLUSIONS

It is the opinion of the investigator in as far as he can judge from the tests, it was possible to make, and with not having tested the machine on the work for which it is the most used, namely; the straightening of short shafting etc., that it will give satisfaction in its capacity when the suggested improvements have been made.

The data here given on the power required for press fits shows that considerably larger allowances could be used on this machine. Halsey's Handbook shows that larger allowances on ground shafts and reamed holes would take considerably more power than the machine is capable of.

The data also shows that it is impossible to make a press fit of this kind without lubrication.

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