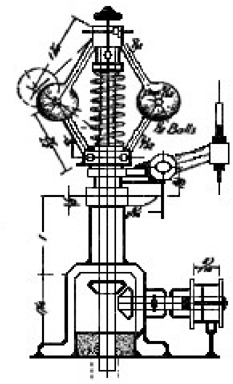


The NEMES Gazette

NEW ENGLAND MODEL ENGINEERING SOCIETY INC.

No 262 April 2018

Gazette Staff

Editor Bob Timmerman

Publisher Jeff Del Papa

NEMES officers

President Dan Erying

Vice President Victor …Kozakevich

Treasurer Richard Baker

Secretary Todd Cahill

Webmaster Jeff del Papa

NEMES web site

http://www.neme-s.org

Contact Addresses

Dan Eying Presidet deyring2017@outlook.com

Richard Baker: Treasurer

treasurer@neme-s.org

Jeff DelPapa: Publisher

Publisher@neme-s.org

Bob Timmerman: Editor

editor@neme-s.org

Bob Timmerman::Program

rwtimmerman@gmail.com

Program

The NEMES program will be held at 7 PM on Thursday, April.5, 2018, in the Jackson Room of the Charles River Museum of Industry and Innovation. The new entrance to the Museum will be open, so you come though that way. Stop and take a look at the improvements.

The meeting agenda will be: A talk by our own Bob Timmerman on Belt Drives, both modern V belts, and the old fashioned flat belts that drive our older machine tools. Bob will explain how to get power from one shaft to another, usually at a different speed. He will also explain some of the special characteristics of the flat belt drives on vintage machinery.

Table of Contents

Club Business

Rich Baker

Dues. The 2018 dues are past due. Please bring your $25 check to the April meeting or you can try out our credit card system. Or mail me a check to Rich Baker, NEMES, 288 Middle Street, West Newbury, MA 01985

President's Corner
Dan Erying

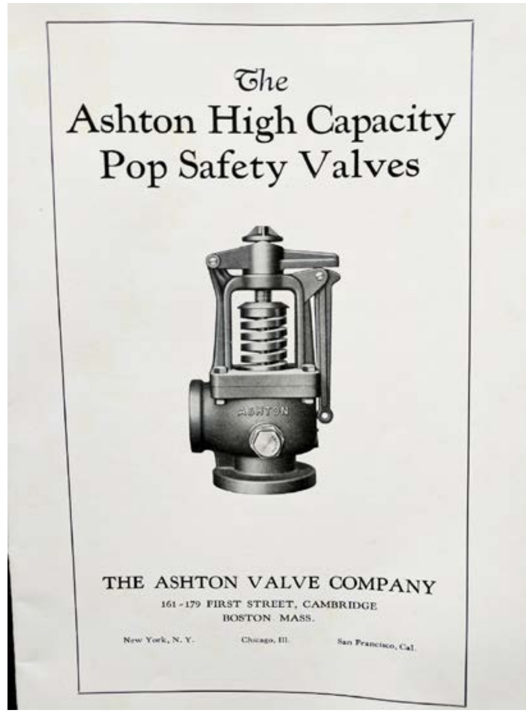
The Ashton Valve Company

So here's a treat for Live Steamers with an interest in the early technology of steam engines and their boilers.

Two weeks ago we were contacted by Rick Ashton of Milford, MA. What he told us is best summarized by his recent posting to an on-line forum.

"My name is Rick Ashton and my great great great grandfather,Henry G. Ashton , started the Ashton Valve company in 1872. The company was built on the popularity of his patented "pop" safety valve. I've been researching the Ashton Valve company for the last year and a half; trying to learn about the company and it's place in the history of steam. I would love to hear from anyone who might have information or pictures relating to Ashton Valve company."

The pop safety valve, patented by Henry Ashton in 1877, was sold (very successfully) as an improved pressure relief valve for locomotive, steam boat and other boilers.



Ashton valve was started in 1871 when Henry Ashton, then working for Hinkley Locomotive Works, invented his pop safety valve. They settled in at 271 Franklin Street Boston around 1878 and remained there until they built their own plant at 161 First street in Cambridge, Ma around 1907. The building still stands today. See pic below. Sometime in the late 1940's they merged with Crosby Steam and Gage Company and moved to Wrentham, Ma ,taking over the building previously owned by Winter Bros tap and die co. The valves and gages continued to be produced until the late 1980's. Some valves were still being produced in the early 90's.

Initially the company primarily manufactured steam gages, safety valves, and air gages for railroads and locomotives. By the early 1900's, the company's advertising touted a much longer product list:

" Manufacturers of the Ashton Lock-up Pop Safety Valves for Locomotive, Stationary, Marine and Portable Boilers, Ashton Water Relief Valves, Hydraulic Relief Valves, Cylinder Relief and Shifting Valves and Ashton Pressure and Vacuum Gages of Every Description, Also, Revolution Counters, Engine Registers, Locomotive and Marine Clocks, Pressure Recording Gages, Water Gages, Gage Cocks, Water Columns, Test Pumps, Thermometers, Pyrometers, and Engine and Boiler Steam Specialties in General".

Fortunately for us, Rick Ashton has built a great collection of Ashton product, spanning much of their product line. Facing pending retirement, Rick called us seeking an appropriate home for his collection.

Shortly thereafter, Bob Timmerman and I trekked out to Milford to spend a fun morning meeting Rick and his Wife – and making a selection of items to bring back to the Museum. They will go on exhibit sometime this summer to the general public. But NEMES will get an earlier look at the Ashton collection when Rick speaks at the May meeting about Henry Ashton, The Ashton Valve Company and Rick's own obsession with collecting and preserving the history and artifacts of his ancestor's company.

So the May meeting will be one you don't want to miss.

Dan

From the Editor's Desk

Bob Timmerman

Rich Baker has provided some upcoming events. Are there any more? If so, I will add them to the May Gazette. If anybody knows of other upcoming events, be sure they get on the website.

We still need more articles. In this issue we have an article from Max about Hexapods, and an article from me about Flat Belts, a follow up on my V-belt article, but what about all you machinists out there—you must have some interesting projects to write about.

.

March Meeting

Dan Erying gave a presentation on the Boston Associates, the venture capitalists who founded the Boston Manufacturing Company in Waltham, and went on found the City of Lowell, and many other textile cities in New England. Dan drew upon the research that the Charles River Museum has done on the Boston Associates. These were people who made their money in shipping, and were looking for a less risky way to put their money to work.

HEXAPODS

Ref: https://en.wikipedia.org/wiki/Stewart_platform

A Stewart Platform (more properly a Gough-Stewart Platform), is a type of parallel robot that has six prismatic actuators, commonly hydraulic jacks or electric actuators, attached in pairs to three positions on the platform's baseplate, crossing over to three mounting points on a top plate.

Because the device has six jacks, it is often also known as a *hexapod* (six legs).
The trademarked name "hexapod" (by Geodetic Technology) was originally for Stewart platforms used inmachine tools. However, the term is now used for 6-jack platforms outside of the machine tool area, since it simply means "six legs".

Devices placed on the top plate can be moved in the six degrees of freedom in which it is possible for a freely-suspended body to move. These are the three linear movements x, y, z (lateral, longitudinal and vertical), and the three rotations pitch, roll, & yaw. The terms "six-axis" or "6-DoF" (Degrees of Freedom) platform are also used, also "synergistic".

If the usual X-Y-Z slides of a machine tool are considered to be "analog", like a LP record, then the hexapod concept may be considered the equivalent of replacing analog by "digital", just as the digital "pits" on a CD disk replace the mechanical "wave" on the vinyl.

The specialized six-jack layout, first used by Dr. V E (Eric) Gough of the UK, was operational in 1954. Dr. Gough (d. 1972), was an automotive engineer who worked at Fort Dunlop, the Dunlop Tyres factory in Birmingham, England.He developed his "Universal Tyre-Testing Machine" (also called the "Universal Rig") in the 1950s. It was operational by 1954. First application of the rig was the mechanically testing of tires under combined loads. It continued to be used up until the late 1980s when the factory was closed down and then demolished. Gough's rig was saved by the Science Museum (London).A rebirth of interest in mechanical testing machine based on the Gough-Stewart platform occurred in the mid '90s.

The design was later publicized in a 1965 paper by D. Stewart to the UK Institution of Mechanical Engineers. Although the short title Stewart Platform is now used for this jack layout, it would be fairer to Eric Gough to call it a Gough/Stewart platform. To be more precise, the original Stewart platform had a slightly different design

Stewart platforms have applications in flight simulators, machine tool technology, crane technology, underwater research, air-to-sea rescue, mechanical bulls, satellite dish positioning,telescopes and orthopedic surgery.

Hexapods are currently used in the amusement park industry, to give a sensation of movement while the rider is actually relatively stationary. An example of such a ride is "Body Wars" at Disney World in Orlando.

Stewart platform designs are extensively used in flight simulation, particularly in the so-called full flight simulator for which all 6 degrees of freedom are required.

.

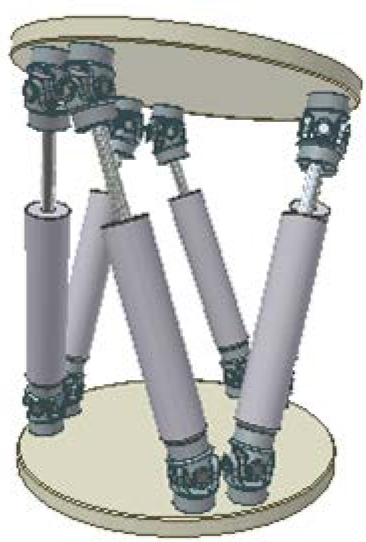
A Stewart Platform in use by Lufthansa

This application was developed by Redifon, whose simulators featuring it became available for the Boeing 707, Douglas DC-8, Sud Aviation Caravelle, Canadair CL-44, Boeing 727, Comet,Vickers Viscount, Vickers Vanguard, Convair CV 990, Lockheed C-130 Hercules, Vickers VC10, and Fokker F-27 by 1962. In this role, the payload is a replica cockpit with a visual display system showing the outside-world visual scene (to the aircraft crew being trained). Payload weights in the case of a full flight simulator for a large transport aircraft can be up to about 15,000 kilograms.

Similar platforms are used in driving simulators, typically mounted on large x-y tables to simulate short term acceleration. Long term acceleration can be simulated by tilting the platform, and an active research area is how to mix the two.

They are often used in biomedical applications (for example spinal study) because of the complexity and large amplitude of the motions needed to reproduce human or animal behavior. Similar requirements are also encountered in the civil engineering field for seismic simulation. Controlled by a full-field kinematic measurement algorithm, such machines can also be used to study complex phenomena on stiff specimens (for example the curved propagation of a crack through a concrete block) that need high load capacities and displacement accuracy.

A hexapod machine tool consists of:
• A Stewart platform positioning system
• A supporting structure.



Because the motions are produced by a combination of movements of several of the jacks, such a device is sometimes called a *synergistic motion platform*, due to the synergy (mutual interaction) between the way that the jacks are programmed.

Add a . . .
• A machining head
• Computer controls
• Work clamps

. . . and you have a hexapod machining center.

At one time, HEXEL, a company, in New Hampshire, marketed a machine, that was a retrofit for non-CNC Bridgeport mills, designed for production. It left the table in place, but the ram was reversed, so that the milling head was moved to the rear of the machine. A Stewart Platform, resting on the floor, moved the work under the head. I have not been able to find any new information about Hexcel, but several companies market Stewart Platforms.

Most of the research work on hexapods was done by large organizations including Giddings & Lewis, Ingersol, Hexel, and MIT. Cincinnati Milacron was interested at one time, but their enthusiasm seems to have evaporated.

The hexapod technology would not have been possible in the past (before the computer revolution, say) because of the considerable computing power required for the large numbers of trigonometric functions and matrix operations needed for CAD tool-path determination, not to mention moving. each of 6 control arms simultaneously in order to make a linear cut.

These days, the availability of powerful desk-top PCs and laptops allow this technology to become feasible, even for amateurs.

Max ben-Aaron maxxam.357@gmail.com

Flat Belt Drives—A Companion to the Article on V Belts

Flatt belt drives have been around since the early days of power driven machinery and were used in early textile mills to transmit power from the line shafts to the individual machines. In 1828, Paul Moody, the millwright of the Waltham mill, who subsequently went to Lowell to build the mills there, used large flat belts to transmit all the power from the water wheels of the Appleton Mills to the line shafts, replacing the expensive and troublesome bevel gears then in use.

While V belts have supplanted flat belts in most applications, they still have a use in high speed drives, where the low mass of flat belts reduces centrifugal forces. While V belts are generally limited to belt speeds of about 6,000 feet per minute, flat belts have been run at surface speeds as high as 16,000 feet per minute.

The main reason for studying flat belts is that they were the main means of transmitting power for many years, and almost all old machinery uses flat belts of one form or another. As many of us have some old machinery in our shops, it is useful to know something about them. As an example, both my 9" South Bend lathe, and my 1903 vintage Brown & Sharpe #1 Universal Milling Machine are driven by flat belts.

Flat belts work by friction between the belt and pulley. As the belt is pulled around the pulley, the tension in the belt increases, which increases the force between the belt and pulley, which increases the friction force. V belts operate in a similar way, but the friction force is augmented by the wedging action between the belt and the groove in the pulley. Because the friction force increases as the belt is wrapped around the pulley, the greater the angle of wrap, the greater the friction force, and the more torque the belt can transmit.

Characteristics of Flat Belt Drives

Because flat belts operate by friction between a flat pulley and a flat belt, they have some unique characteristics:

1. They can be spliced with methods that are easily removable. This comes in handy when the belt is driving a machine spindle, and it would be undesirable to remove the spindle from it's bearings. While there are specialized splices for V belts, flat belts can be spliced with either a specialized splice, or by a simple laced splice. The specialized splice is known as a "Clipper Lacing". While it takes a special tool to install it, the Charles River Museum has one, and it might be possible to make arrangements to get the splice installed. Probably the belt dealer that supplied the belt could also install the splice. The laced splice is described in the South Bend Lathe Book "How to Run a Lathe". These splices can be made up with leather thongs commonly used for lacing work boots. They require a moderately thick belt to work properly. I had to redo the one on my 9" South Bend, but the laced splice I did has been working well for about 10 years.
2. If a permanent splice is desired, flat belts can be glued together.
3. They can act as a clutch in a number of ways. The simplest way, is to slack off the belt tension. The drive on the 9" South Bend uses a toggle linkage for belt tension, permitting belt tension to be easily slacked off to stop the lathe. Another common way was to use two pulleys, one fastened to the driven shaft, and the other free to run on the driven shaft. This is called a "tight and loose pulley". When the machine is stopped, the drive belt is running on the pulley free to run on the driven shaft (the "loose pulley"). When it is desired to run the machine, a belt shifting arrangement is used to shift the belt onto the "tight pulley". The Charles River Museum has this arrangement on most of the machines in the belt driven shop, and all work well. Their Pratt and Whitney planer uses two drive belts, on open, and one crossed, permitting the table to be driven in both directions. There are two tight pulleys, and one loose pulley between the tight pulleys. A belt shifter operated by trip dogs on the table shifts the belt between the forward direction tight pulley and the reverse direction tight pulley. The belt not in use idles on the loose pulley in the middle.
4. If belt tension can be adjusted, the belt drive can be set to slip on overload. Because flat

belts do not grab as V belts to, this is easier to do and more precise with flat belts than with V belts.

5. If the center to center distance of the two shafts is longer than about 2 or 3 times the sum of the pulley diameters, the belt can be crossed, so that the direction of rotation is reversed. Crossed belts have some interesting properties which will be discussed later in this article.
6. Because the mass of flat belts is lower than that of V belts, they work better than V belts at high speeds, and are still used for spindle drives in ring spinning machines.

Non-Standard Applications of Flat Belts

Flat belts can be used as right-angle drives. Short belts can sometimes be used at right angles without guide pulleys, long belts usually require them. One common application is line shaft driven drill presses, where the belt from the horizontal jackshaft makes a right angle turn to drive the vertical drill press spindle.

Another application is the V-flat drive, which is a short center distance drive with fairly high reduction. A V pulley is the driver (usually on an electric motor), and a flat pulley is used as the driven pulley, usually due to lower cost than a large V pulley. This drive makes use of the ability of a small V pulley to grip the belt with a relatively small angle of wrap, while the angle of wrap around the large pulley is adequate for it to grip as a flat belt. As the bottom of the belt is what grips the large pulley, the surface speed that governs the speed ratio is the speed off the bottom of the belt.

The attached picture shows the V-flat drive on my milling machine, taking advantage of a large flat pulley that I acquired with some other used machine.

The motor pulley is 3 1/8" OD, the belt is riding down about 7/32", and the belt is 3/8" thick. Subtracting twice the belt thickness and twice the amount the belt is riding below the rim, and we get a pulley diameter slightly under 2". The flat pulley is 20" diameter, giving a reduction ratio of 10:1 .

The belt tracks fairly well, and easily handles the motor rating of ½ hp.

Sources of Flat Belting

Leather belts are still available, but are expensive. One on-line source is Leatherdrivebelts.com, but they only sell single ply belts 11/64" thick. This may be too thin for some applications. Another on-line source is Albinoindustrialbelting.com, who has greater thickness available. Locally, the web page of Page Belting in New Hampshire (pagebelting.com) has a long list of belt thicknesses available, but provides no pricing. They prefer to have customers for leather belting talk to their salesmen. Olmstead-Flint in Woburn claims to carry a leather-nylon composite belting.

The majority of flat belting today is synthetic, composed of rubber outer layers with a fabric reinforcing. This is also used for conveyor belting, so it is more readily available. In addition to Olmstead-Flint mentioned above, Page belting stocks a rubber-fabric belt, which appears similar to that which the Charles River Museum uses in their flat belt driven shop.

One leather belting vendor charges a total of $0.77 per square inch for 11/64" belting, which is about equivalent to Page #107 fabric reinforced rubber, for which they charge $0.80 per foot per inch of width. The resulting cost of leather belting is about 12 times the cost of synthetic

Theory

The torque that a belt will transmit depends upon the initial tension, the angle of wrap, and of course the pulley diameter. The difference in tension between the tight side of the belt and the loose side produces a torque on the pulley, which transmits power.

The torque $=(T_{tight}-T_{loose}) \times R$

where T_{tight} is the tension on the tight side of the belt

T_{loose} is the tension on the loose side of the pulley

R is the radius of the pulley.

The tension in the tight side depends upon the tension in the loose side, and the angle of wrap. For an open belt, the angle of wrap is (to within 0.5%)

$A= 180-[60(D-d)/l]$

where D is the diameter of the large pulley

d is diameter of the small pulley

l is the center to center distance.

Formulas have been derived for the arc of contact for crossed belts, but they are somewhat complex. It can be shown that the arc of contact of a crossed belt is always greater than 180 degrees, and is the same for both pulleys, regardless of diameter. For practical purposes, one can use 180 degrees as the arc of contact for crossed belts, which will give a conservative answer.

The attached photo of the Pratt and Whitney planer at the Charles River Museum illustrates the difference in angle of wrap. One belt is open, for the cutting stroke, while the other belt is crossed, for the return stroke. Trip dogs on the table shift the belts from loose to tight pulleys to operate the planer.

It can clearly be seen that the angle of wrap is more for the crossed belt.

With the angle of wrap known, the tight side tension is:

$T_{tight}= T_{loose} \times e^{(\text{angle of wrap}/57.3) \times f}$

Where T_{tight} and T_{loose} are the tensions on the tight and loose sides

e is the base for the exponential function

angle of wrap is in degrees

57.3 converts it to *radians* which is angle measure needed for the exponential function

f is the friction factor, usually taken as 0.3

This theoretical function can be used to calculate the difference in tension, and the torque.

Power is simply the difference in tension in pounds, times the belt speed in feet per minute.

Belt Ratings

In practice, the power rating of flat belts is usually given in tables based on ideal conditions, which is then corrected for angle of wrap, minimum pulley diameters, and service conditions. Belting catalogs today give minimum pulley diameters which generally are smaller than the ones given in the rating tables. One should refer to the catalog minimum pulley diameter. For the service in which most machine tools are used for, one probably only need include the angle of wrap, and the type of belt joint.

Marks Handbook states that a glued joint is as strong as a leather belt, so no derating is needed. A Clipper joint is 85% to 90% as strong, so a slight derate is needed. A laced joint is only 1/3 as strong as a leather belt. [While I did have to replace the laced joint in the belt on my South Bend lathe, I have had no further problems with it.]

The laced joint is best reserved for light duty use, with the Clipper joint being the joint of choice for general purpose use.

The following is an abbreviated version of Table 49 on page 8-51 of the 8th edition of *Marks Mechanical Handbook*

Ratings of flat belt drives, hp/inch of width
Based on Table 49 in Ch. 8 of 8 ed Marks Handbook

Belt Speed	Single Ply Belts		Double Ply Belts		
ft/min	11/64"	13/64"	18/64"	20/64"	23/64"
600	1.1	1.2	1.5	1.8	2.2
800	1.4	1.7	2.0	2.0	2.9
1,000	1.8	2.1	2.6	3.1	3.6
1,200	2.1	2.5	3.1	3.7	4.3
1,400	2.3	2.9	3.5	4.3	4.9
1,600	2.8	3.3	4.0	4.9	5.6
1,800	3.2	3.7	4.5	5.4	6.2
2,000	3.3	4.1	4.9	6.0	6.9
2,200	3.9	4.5	5.4	6.6	7.6
2,400	4.2	4.9	5.9	7.1	8.2
2,600	4.5	5.3	6.3	7.7	8.9
2,800	4.9	5.6	6.8	8.2	9.9
3,000	5.2	5.9	7.2	8.7	10.0
3,200	5.4	6.3	7.6	9.2	10.6
3,600	5.9	6.9	8.3	10.1	11.7
3,800	6.2	7.1	8.7	10.3	12.2
4,000	6.4	7.4	9.0	10.9	12.6
5,000	7.4	8.4	10.3	12.5	14.3
6,000	7.8	8.9	10.9	13.2	15.2

These ratings need to be adjusted for the arc of contact. Arc of contact factors are tabulated below, based on Table 55 in chapter 8 of the 8th edition of Marks Handbook, extended to smaller arcs of contact by the author.

Arc, deg	100	120	140	160	180	200
Factor	0.66	0.73	0.82	0.93	1.00	1.06

Using my milling machine as an example, with a 10:1 ratio on a 1750 rpm motor, the jackshaft turns at 175 rpm. The smallest diameter on the cone pulley is 4.5 inches, which gives a belt speed of about 200 feet per minute. The table only goes down to 600 feet per minute. At low speeds it is possible to extrapolate. The belt is 19/64" x 2 15/16". Interpolating between the 18/64" and 20/64" at 600 ft/min, we get about 1.65 hp/inch. Extrapolating that down to 200 ft/min, we get a rating of about 0.55 hp/inch. The angle of wrap is estimated at 170 degrees, so we can neglect that.

The belt is fastened with Clipper lacing, so the hp/inch is 85% of 0.55, or about 0.47 hp/inch. Use 0.50 hp/inch. The belt is 2 15/16" wide, use 3", so the belt is rated at about 1.5 hp. In practice, the belt runs on very short centers, probably about 40",and the center to center distance is fixed, so there is no way to adjust the tension. Because of this I have to keep the belt looser than it should be so that I can shift it from one pulley to another. As a result, the belt sometimes slips when driven by a ½ hp motor. Belt dressing keeps it running.

Bob Timmerman

Future Events

Granite State Gas and Steam Engine Association, 47th Annual Gas and Steam Spring Show, June 2-3, 2018, JR Bristol's, 80 Witches Spring Rd, Hollis, NH, http://granitestategasandsteamengineassociatoin.com

Bristol's Round-up and Tractor Pull, May 20, 2018, JR Bristol's, 80 Witches Spring Rd, Hollis, NH.

East Coast Antique Tractor Club, Spring Tractor Pull and Swap Meet- (Rain or Shine), June 3, 2018, J.R. Rosencrantz, Kensington, NH, Contact: Jim Rosencrantz 603-765-8235

East Coast Antique Tractor Club, 142nd Deerfield Fair- September 27-September 30th, Deerfield, NH- Contact: Jim Rosencrantz, 603-765-8235

.