lighter than metal for the same strength, although it is much more bulky.

On an aeroplane the bulk of wood required is not disproportionate to the present size of the machine—whatever it may be in the future—and in consequence it has become a very popular material. Only two notable examples of steel need be referred to, the Breguet and the R. E. P. In the latter case the frame is comparatively small, and in the former it is very extensive, and, in fact, forms an interesting example of tubular steel work quite apart from any reference to its application to the subject under discussion.

Most of the monoplanes have boat-like frames of V section, which gives some of them the appearance of racing skiffs; in a few cases, the sides are actually wood-covered, at any rate in part, but in general the frame is a light skeleton structure covered with fabric. In general, such frames taper in section aft, and either have a bluff end forward or a short sharp point. A feature of the Wright frame is the detachability of the struts between the two main planes; the ends of the struts are fitted with steel screw-eyes, which fasten on to corresponding curled hooks. Diagonal wire stays give the necessary stiffness in conjunction with the runners, which form a base for the machine as well as a support for the elevator in front.

SURFACE MATERIALS

Fabric, made of Egyptian cotton treated with rubber, constructed by the Continental Tyre Company, is a popular surface material for covering the wings of aeroplanes, as it is readily obtainable in any weight and strength, and is impervious to rain. Some of the machines, however, use other things, as, for instance, the Bleriot No. 9, which has a vellum-like paper covering; the Bayard-Clement, which employs varnished silk; and the Antoinette, which uses varnished linen. This latter is hand polished to give great smoothness, and has a fine glossy finish; so, too, has the silk of the Bayard-Clement monoplane, but the fabrics are not usually prepared with a specially smooth surface.

SYSTEMS OF CONTROL.

There is no more interesting feature of the aeroplane, nor one in which greater difference in detail finds expression in practice, than the system of control. Especially is this the case in connection with the steering and elevating levers themselves, all kinds of devices having been adopted by the different inventors as being most in accord with their own individual ideas on the subject. So far as the actual means of maneuvering the machine are concerned, the difference is naturally less marked, for most of them have well-defined rudders and elevators.

In the monoplane type of machine there is greater variety in the details of control than with the biplanes, the differences in the latter class being mainly concerned with the placing of the rudder aft and elevator forward, or vice versa. On the monoplanes, however, the main wings themselves are generally brought into play in one way or another, either by total flexion or warping as on the R. E. P. and Vendôme aeroplanes, or by the use of steering tips as on the Bleriot No. 9 and Antoinette. In the R. E. P. monoplane the warping of the wings in opposite directions simultaneously serves for all ordinary maneuvering without resorting to the rudder, which is under the control of a separate lever. Rising and falling is accomplished by tilting the elevator by a to-and-fro motion of the same pivoted lever which warps the wings. On the Vendôme monoplane each wing is warped by a separate lever, and as these levers are very massive and pronounced, standing out well above the frame, the pilot must assume somewhat the same attitude as is presented by the driver of a traction engine, who is ordinarily seen wending his way with each hand firmly grasping a handle.

Although, as in the R. E. P. monoplane, the warping of the wings is used for the purpose of steering, it is necessary to draw a distinction between such arrangements and the rudder pure and simple, because for the most part they are provided to assist in maintaining stability, quite apart from any use which they may have for governing direction. It is in this capacity, too, that the designers regard the use of steering-tips, which consist of small pivoted extremities attached to the ends of the main wings. Being at a great distance from the center of the machine, they have a considerable leverage, and operating as they do upon both sides of the center simultaneously, the rapidity with which they are able to produce an effect is enhanced. It is, therefore, upon this device that the pilot mostly relies to keep his equilibrium. The warping of the main planes is, as our readers know, one of the great features of the Wright aeroplane; but in the machine exhibited, the movement is accompanied by a turning of the rudder; the elevator on the Wright aeroplane is under the control of a separate lever.

As to the levers themselves, custom differs widely, as we have already mentioned. Wright (on the machine exhibited) uses two simple rods, one hinged to rock laterally for steering, the other to move to and fro for rising and falling. In the Farman, Delagrange, and Kapferer aeroplanes, the pilot clutches a steering wheel similar to that used on a motor car, but placed in a vertical plane; for steering, it is turned as on a boat, while for varying the altitude of flight it is pulled or pushed bodily to and fro. Such a system as this, it will be observed, allows either or both hands to do all the work that is required. On the R. E. P. and Breguet machines the system of single-lever control has been restricted to the pilot's left hand, the lever in question on the R. E. P. monoplane being pivoted universally to move in any direction; while the Breguet system is to fit the elevating lever with a rotary handle which is twisted for the purpose of steering.

In the following tabular summary, brief particulars, so far as they are available, are given of the methods of control adopted on the various aeroplanes exhibited:

One-Hand Control.

"Bleriot No. 9."—Pivoted lever, fitted with steering-wheel handle. Moves to and fro to ascend (elevator), and sideways to turn (rudder and steering tips).

"Voisin" (Delagrange and Farman).—Vertical steering-wheel. Rotates to turn (rudder), and is pulled or pushed to go up or down (elevator).

"Astra" (Kapferer).—Same as "Voisin."

"R. E. P."—Three levers. One moves to and fro to ascend (elevator), sideways for stability and to steer (warp wings); one sets rudder; and the third works the elevator or horizontal rudder.

Hand and Foot Control.

"Bleriot No. 10."—Pivoted lever fitted with steering-wheel handle. To and fro to ascend (elevators), sideways for stability and to turn (elevators); foot rudder.

"Bleriot No. 11."—Pivoted lever as on No. 10. To and fro to ascend (elevators); sideways for stability and to turn (warp wings); foot rudder.

"Breguet."—Hinged lever with pivoted handle. To and fro to ascend (elevator), rotate handle to turn (rudder), foot operates extra steering planes.

"Vendome."—Three levers and two pedals all separate. Two levers to warp wings, separately or together (steering or ascending); one lever to set tail (long ascents); two pedals to work steering tips separately (sharp turning).

Two-Hand Control.

"Antoinette."—Rudder operated by ropes; steering tips by another rope; elevator by a wheel at the pilot's side.

"Clement."—One lever and one wheel; lever for elevator, wheel for rudder.

"Wright."—Two levers; one for elevator, one for rudder and warping wings.—Automotor Journal.

THE DESIGN OF CYLINDERS FOR THE STORAGE OF CARBONIC ACID.*

By REID T. STEWART, M.Am.Soc.M.E.

CARBONIC acid as commercially handled may exist in three distinctly different states—the gaseous, the vaporous, and the liquid.

Commercial carbonic acid is manufactured, collected as a by-product or from natural sources, as either a gas or a superheated vapor. After being compressed and cooled sufficiently, this gas or vapor is converted into a liquid, which is charged into steel cylinders for transportation to the consumer.

From the standpoint of the physicist the critical temperature is that temperature above which a substance always exists in the gaseous state, for at temperatures above the critical temperature no substance has yet been reduced to the liquid state by any pressure, however great; while for temperatures below the critical temperature all the commonly occurring gases have been liquefied.

The critical temperature of purified and dried carbon dioxide, as determined by Amagat, is 31.35 deg. C., or 88.4 deg. F. He has compressed the gas while above this temperature to a pressure approximating 15,000 pounds per square inch, and thus to a density about 10 per cent greater than that of water, without reducing it to a liquid. For any temperature below this critical temperature he found a definite and fixed pressure at which the carbon dioxide could be reduced to the liquid state (e. g., 504 pounds per square inch at 32 deg. F.; 744 pounds at 60 deg. F.; and 1,071 pounds at 88.4 deg. F., or the critical temperature).

An investigation of the relative merits of the different formulas that have been published for the strength of tubes which are subjected to internal fluid pressures, has led the author to the belief that Claverino's formula is the most reliable, when the tube wall is subjected to both the transverse and longitudinal stresses due to the internal fluid pressure; as is the case in a carbonic acid cylinder.

The author has produced an exceedingly close approximation to Claverino's formula for values of t/D less than 0.1, which fully covers the range in values of t/D for the conditions of minimum weight of cylinder per unit weight of contained carbonic acid. This very close approximate formula for steel carbonic acid cylinder conditions, gives the relations: $D/t = 2.325\ f/p$, or $t/D = 0.43\ p/f$; where D = outside diameter of cylinder in inches, t = thickness of cylinder wall in inches, f = fiber stress in wall of cylinder in pounds per square inch, and p = internal fluid pressure in pounds per square inch.

Table I.—Thickness and Charging Factors for Carbonic Acid Cylinders for Minimum Weight of Steel in Shell per Unit Weight of Acid Contained.

Fiber Stress in Wall, Lbs. per Sq. Inch.	Factors for Thickness of Wall (t/D) Greatest Temperature Change in Cylinder. 100° F.	110° F.	120° F.	130° F.	140° F.	150° F.
15,000	.0398	.0452	.0499	.0542	.0581	.0616
16,000	.0375	.0425	.0470	.0511	.0547	.0581
18,000	.0334	.0379	.0419	.0455	.0487	.0518
20,000	.0300	.0341	.0377	.0410	.0439	.0468
24,000	.0261	.0285	.0316	.0344	.0370	.0393
27,000	.0223	.0254	.0282	.0307	.0331	.0353
30,000	.0202	.0229	.0254	.0278	.0299	.0320
* Mean density of CO_2	.65	.63	.61	.59	.57	.55
* Lbs. CO_2 per cu. inch	.0235	.0228	.0220	.0212	.0205	.0198
* Lbs. CO_2 per U. S. gal.	5.42	5.27	5.07	4.90	4.73	4.57

* Substantially correct for fiber stresses from 15,000 to 30,000 lbs. per sq. inch.

Table I. is based upon the results of laboratory experiments on purified and dried carbon dioxide. It is therefore directly applicable to the storage in steel cylinders of chemically pure acid.

Assuming, for instance, the maximum working fiber stress in the wall of a cylinder to be 18,000 pounds per square inch, and the maximum storage temperature of the carbonic acid to be 120 deg. F., we find from Table I. the corresponding thickness factor, t/D to be 0.0419. For these conditions, then, a cylinder of 6 inches outside diameter should have a thickness t, equal to 0.0419×6, or 0.2514 inch, which is approximately ¼ inch.

For calculating the fiber stress in the wall of a carbonic acid cylinder, use the formula given earlier, transposed to read:

$$f = 0.43\ pD/t.$$

This simple formula gives results, which, for carbonic acid cylinder conditions, approximate exceedingly close to those obtained by the use of Claverino's theoretically correct formula, which is

$$f = p\ [4D^2 + (D - 2t)^2]/3\ [D^2 - (D - 2t)^2]$$

Table II.—Pressure Exerted by Carbonic Acid Against Walls of Cylinder in Pounds per Square Inch.

* Density.	100° F.	110° F.	120° F.	130° F.	140° F.
.55	1270	1450	1630	1810	1995
.57	1290	1475	1670	1860	2055
.59	1310	1505	1710	1915	2125
.61	1330	1540	1760	1975	2200
.63	1355	1580	1815	2045	2285
.65	1395	1630	1875	2120	2375

* Density.	150° F.	180° F.	200° F.	212° F.	....
.55	2180	2735	3110	3340	....
.57	2255	2845	3245	3490	....
.59	2335	2970	3395	3655	....
.61	2425	3100	3555	3835	....
.63	2525	3240	3725	4020	....
.65	2630	3395	3910	4225	....

* Taking water at 39.2° F. as unity.

Table II. gives the absolute fluid pressures of pure carbonic acid gas in pounds per square inch. When the air content is excessive, a correction of about 60 pounds increase in tabular pressure should be made for each per cent of air contained in the carbonic acid, for temperatures ranging from 100 to 140 deg. F.

A cylinder having a water capacity of 33 pounds when charged with 20 pounds of commercial acid, corresponding to a tabular density of 20/33 or 0.61, and having an air content of 2 per cent, when at a temperature of 120 deg. F., will be subjected to a fluid pressure, according to Table II., of $1,760 + (60 \times 2)$, or 1,880 pounds per square inch. If now this cylinder have an outside diameter of 6 inches, and a thickness of wall of ¼ inch, then the fiber stress in the wall will be $f = 0.43\ pD/t = 0.43\ (1,880 \times 6)/0.25 = 19,400$ pounds per square inch.

* From a paper entitled "The Physical Properties of Carbonic Acid and the Conditions of Its Economic Storage for Transportation," presented at the New York meeting of the American Society of Mechanical Engineers.

The records for November are not available, but indications are that the net result of the movement of aliens to and from the United States is now in favor of this country. In October there was a net influx of 6,249. In November the departures showed a lessening tendency, while the arrivals increased. The arrivals through all ports in October were 40,994, against 111,513 in October, 1907, and 99,974 and 86,758 for that month in 1906 and 1905 respectively. For the first 10 months of this year the arrivals were 327,240, against 1,150,116 and 1,035,602 for the like periods in 1907 and 1906 respectively.