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SOME EXPERIMENTS ON LOSS OF HEAT FROM IRON PIPES.

By R. W. LEONARD, M. C. Soc. C. E.

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The difficulty of obtaining reliable data in convenient form regarding the loss of heat from warm water through the walls of metallic pipes of differing dimensions when exposed to cold air or water under differing conditions, led the writer to make a few experiments during the past winter which was favourable for such purposes. The results of these experiments may be of interest to some members of the society.

A.

1" standard but welded steam pipe. Black—somewhat rusty.

Inside diam	1.048"	
Outside "	1.315"	
Thickness	0.134"	
Length	4.25′	contains 1. 581 lbs. water.
External surface	1.463 sq. ft.	

B.

2" standard but welded steam pipe. Black.

Inside diam	2.067"	
Outside "	2.375"	
Thickness	0.154"	
Length.	3.54′	contains 5 lbs. water.
External surface	2.20 sq. ft.	

C.

2" Galvanized iron pipe. Gauge 28.

Diameter	2"
Thickness	0.016"
Length.	35.3" contains 4 lbs. water.
External surface	1.54 sq. ft.

D.

2" Bright tin pipe. Gauge 26.

Diameter	2"
Thickness	0.018"
Length.	35.3" contains 4 lbs. water.
External surface	1.54 sq. ft.

E.

2" Lap-Welded Charcoal Iron Boiler Tube. Black.

Inside diam	1.810"
Outside "	2.000"
Thickness	0.095"
Length.	41" contains 3.805 lbs. water.
External surface	1.784 sq. ft.

G.

1" standard but welded stem pipe. Galvanized.

Inside diam	1.048"
Outside "	1.315"
Length.	0.134"
Thickness	4.25 contains 1.58 lbs. water.
External surface	1.463 sq. ft.

A. and G. were filled with warm water and exposed under a shed to a temperature of from 16° to 20° F., and the rate of cooling is illustrated in accompanying diagram (Fig. 1).

A. B. C. and E. were filled with warm water and exposed in the open air on a very still day (no perceptible wind blowing) to a temperature of from 7° to 10°F. The rate of cooling is illustrated in Fig. 2, which also illustrates the rate of cooling of pipe B., exposed to a wind at low temperature.

A. B. C. D. E., were filled with warm water and submerged in still water under the ice, and the experiment was repeated in a current of water at 32° flowing at 1½ feet, per sec., and the results are shewn in figs. 3 to 7. Fig. 8 shows the rate of cooling in G in the current. In all cases the pipes wereexposed in a vertical position sheltered from the sun.

All of the diagrams show irregularities which may be attributed to inaccuracies in reading the fine division on the thermometer and to possible irregularity in circulation of the warm water while cooling in the pipes. Apart from these irregularities the differences between figures 1 and 2 are interesting.

In the following table the writer compares the loss in B. T. U.'s per sq. ft., of external surface from the different pipes under the differing conditions.

COMPARISON OF TRANSMISSION FROM VARIOUS TUBES.

Description.	Thickness. Inches.	Ext. Surface Sq. Ft.	Contents. lbs. water.	Loss in B. T. U.'s per sq. ft. per hour.	Temperatures Fahrenheit.
B. 2" Welded Steam Pipe—Black	0.154	2.20	5.00	124.0	From 142 " 32 in still air at temp. 7° to 10° F.
B. 2" " " " "	"	"	"	112.6	" 126 " 32 " " " " " 7° to 10° F.
B. 2" " " " "	"	"	"	217.3	" 126 " 32 " wind 8" to 12" per sec. 5° to 7° F.
B. 2" " " " "	"	"	"	309	" 126 " 32 " still water temp. 32°.
B. 2" " " " "	"	"	"	269	" 116 " 32 " " " " 32°.
B. 2" " " " "	"	"	"	849	" 116 " 32 " current of 1½" per sec. temp. 32°.
E. 2" Lap Welded Boiler Tube	0.095	1.784	3.805	136.7	" 142 " 32 " still air temp. 7° to 10°.
E. 2" " " " "	"	"	"	385	" 142 " 32 " still water temp. 32°.
E. 2" " " " "	"	"	"	1005	" 142 " 32 " current of 1½" per sec. temp. 32°.
A. 1" Welded Steam Pipe—Black	0.134	1.463	1.58	115.0	" 142 " 32 " still air temp. 8° to 10° F.
A. 1" " " " "	"	"	"	297	" 142 " 32 " " water temp. 32°.
A. 1" " " " "	"	"	"	982	" 142 " 32 " current of 1½" per sec. temp. 32°.
G. 1" " " " Galvan.	"	"	"	950	" 142 " 32 " " " " " " " 32°.
C. 2" Gal. Iron Pipe	0.016	1.54	4.00	129.0	" 142 " 32 " still air " " " " " 7° to 10°.
C. 2" " " "	"	"	"	451	" 142 " 32 " still water temp. 32°.
C. 2" " " "	"	"	"	1008	" 142 " 32 " current of 1½" per sec. temp. 32°.
D. 2" Tinned Iron Pipe	0.018	"	"	470	" 142 " 32 " still water temp. 32°.
D. 2" " " "	"	"	"	1224	" 142 " 32 " current of 1½" per sec. temp. 32°.

From the above data it is possible to calculate approximately the amount of warm water it is necessary to pump through the hollow bars of a rack protecting water wheels in order to prevent the accumulation of frazil thereon, as it is necessary to raise the temperature of such bars but a fraction of a degree to accomplish this end.

The curves indicate that water slightly warmed loses its heat much less rapidly than hot water when exposed in a tube to a current of ice cold water.

To illustrate the practicability of this idea the example of one of the units in the extension of the Hamilton Cataract Power, Light & Traction Co.'s plant near St. Catharines may be taken.

The data are as follows :—

Head of water, 267 feet.

Capacity of turbine 245 c. ft., per sec., delivered through steel penstock 6′ 6″ diameter.

Power of each turbine 6,000 H. P.

Rack is 18′ 6″ wide with length of 16 ft. submerged at ordinary water level.

Thin iron pipe can be flattened to serve as bars spaced as desired and connected top and bottom with headers to form sections of the rack suitable for the circulation of warm water under pressure from a pump.

The water area through the rack may be arranged to allow of a current of 1½ feet, per second, thus corresponding with the conditions existing in the experiments quoted above.

Now assume the water for warming the rack to be heated to 66° and returned to the heater at a temperature of 35° after being exposed to a current of 1½ feet per sec., in ice cold water. This loss of 31° takes place in 4 min., from a 1″ boiler tube from 1.6 lbs., of water = 50 B. T. U.'s from a surface of 1.463 sq. ft., or, say, 34 B. T. U.'s per sq. ft., in 4 min. or 510 B. T. U.'s from 1 sq. ft. per hour.

The total pipe surface submerged in such a rack equals 695.3 sq. ft., therefore the transmission of heat from whole rack per hour equals 354,603 B. T. U.'s.

Assume a boiler evaporating 9 lbs., water from and at 212° F. per lb., coal or yielding 8,694, B. T. U.'s per lb., coal (latent heat 966 B. T. U.'s.)

Therefore the coal required per hour to warm water equals 41 lbs., requiring a grate area of 5 sq. ft., (with 8 lbs., coal burned per hour per sq. ft. grate area) or a boiler of 15 H. P.

The quantity of water to be heated may be arrived at as follows:

1.6 lbs., water loses 31 temp., in 4 min., or at the rate of 290 B. T. U.'s per hour.

Total loss from rack (as above) 354,603 B. T. U.'s requiring a circulation of 1223 lbs., per hour or 122 gals., or little over two gals. per min.

In order to avoid difficulties caused by the freezing of the water in the bars of the rack when the heating system is not being used it would be desirable to use some fluid which freezes only at a very low temperature.

It would appear that the same principle can be economically used to prevent the accumulation of frazil on other hydraulic machinery such as water wheel casings, etc.

It will be apparent to the reader that with a lower head of water and a corresponding increased volume, the circulation of a proportionately larger quantity of warm water would be necessary in order to effect the purpose desired, and there comes a point at which the object attained is not worth the expenditure of fuel necessary for the purpose.

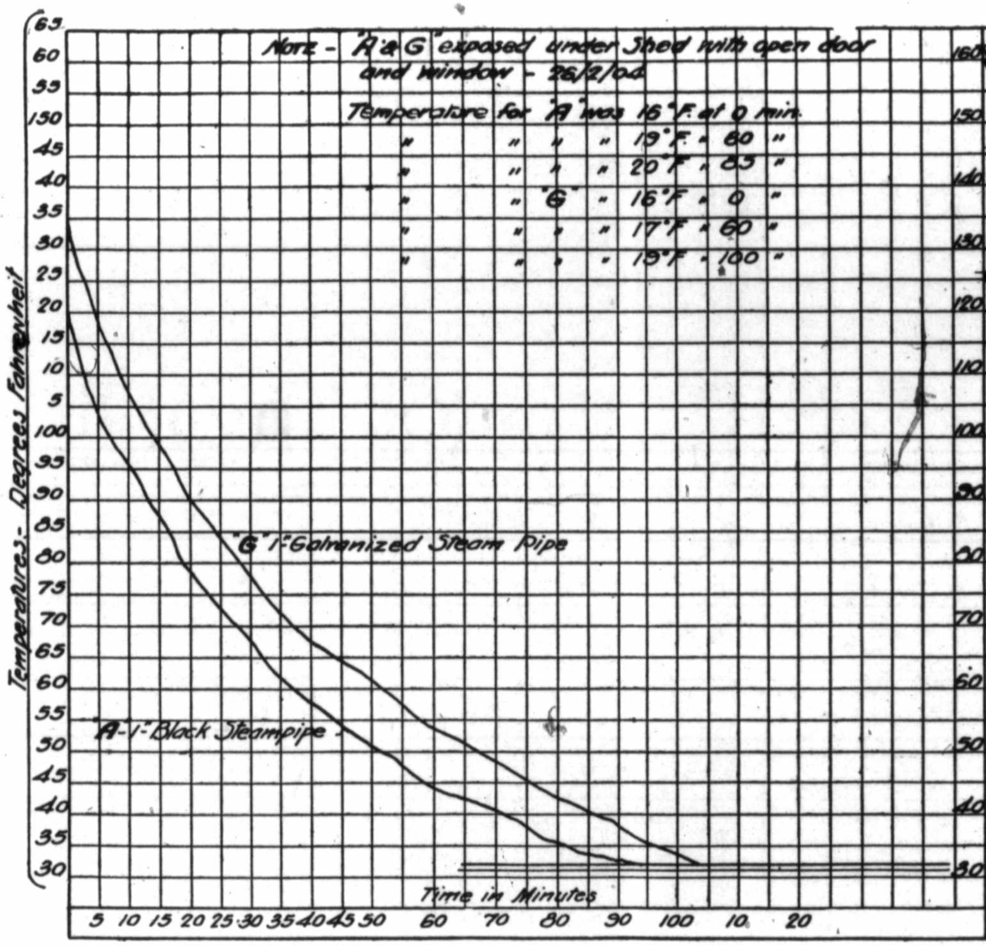
Note - "A & G" exposed under Shed with open door and window - 26/2/04
Temperature for "A" was 16°F. at 0 min.
" " " " 19°F. " 60 "
" " " " 20°F " 85 "
" " "G" " 16°F " 0 "
" " " " 17°F " 60 "
" " " " 15°F " 100 "
Temperatures - Degrees Fahrenheit
"G" 1" Galvanized Steam Pipe
"A-1" Black Steampipe
Time in Minutes

Fig. 1.

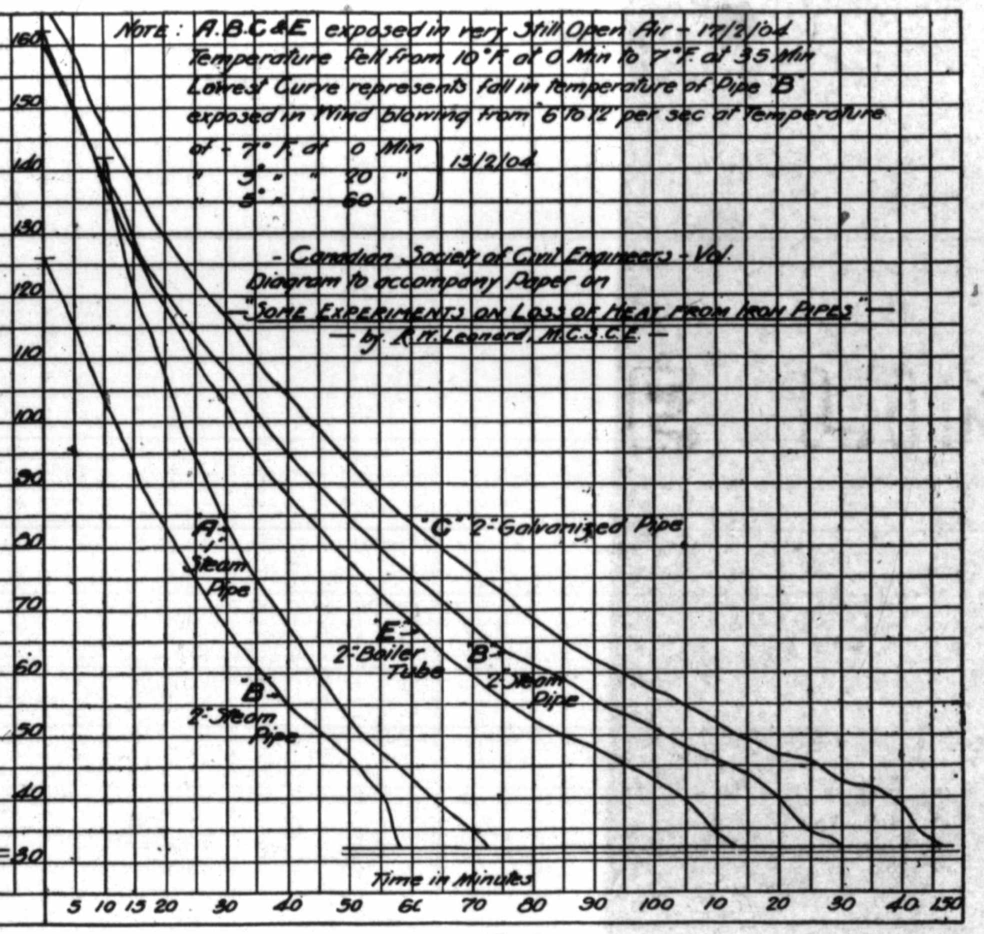
Note: A.B.C & E exposed in very Still Open Air - 17/2/04
Temperature fell from 10°F. at 0 Min to 7°F. at 35 Min
Lowest Curve represents fall in temperature of Pipe "B"
exposed in Wind blowing from "6 to 12" per sec at Temperature
of - 7°F. at 0 Min
" 3° " " 20 "
" 5° " " 60 "
15/2/04
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Diagram to accompany Paper on
"Some Experiments on Loss of Heat from Iron Pipes"
- by R.W. Leonard, M.C.S.C.E. -
"A" 1" Steam Pipe
"B" 2" Steam Pipe
"E" 2" Boiler Tube
"B" 2" Steam Pipe
"C" 2" Galvanized Pipe
Time in Minutes

Fig. 2.

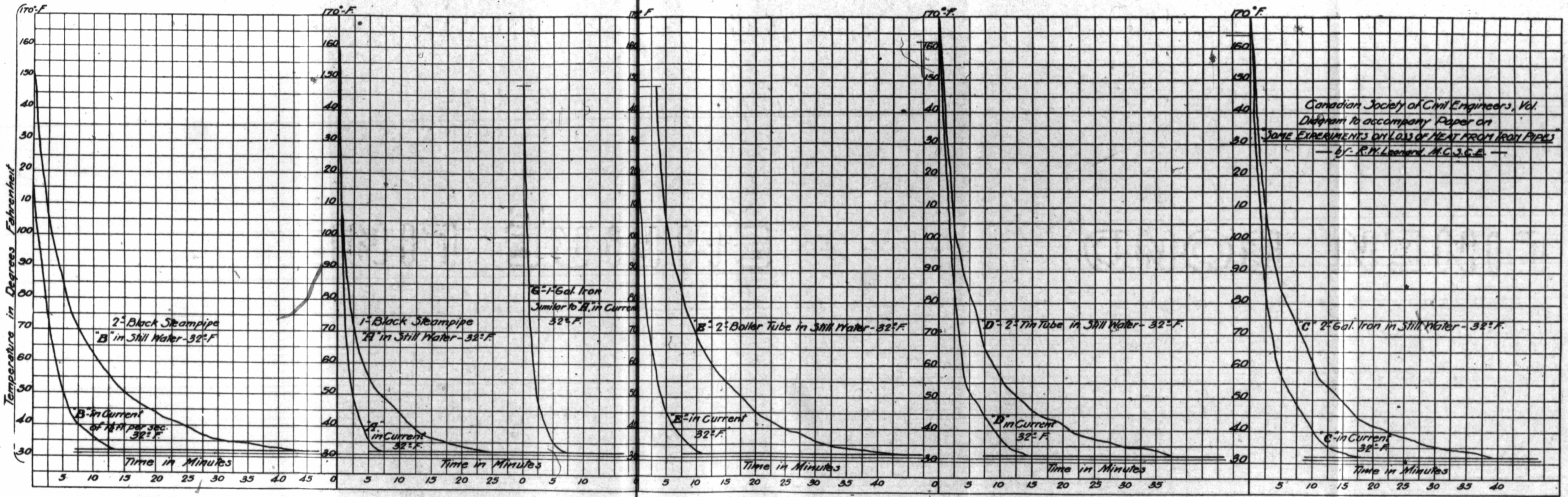

Fig. 4. Fig. 3. Fig. 8. Fig. 7. Fig. 6. Fig. 5.