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MISSING

. . THE CENTRAL . .
Railway and Engineering Club . . . .
OF CANADA

OFFICIAL PROCEEDINGS

Vol. 7
No. 7

TORONTO, CAN., Oct. 28th, 1913

$1.00 per year
15c. per copy

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Published every month, except June, July and August, by The Central Railway and Engineering Club of Canada.
C. L. WORTH, Sec.-Treas., Room 409, Union Station, Toronto
Phones: Day, Main 4860.
Night, North 346.

PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA MEETING.

COURT ROOM NO. 2, TEMPLE BUILDING,

TORONTO, October 28th, 1913.

The President, Mr. A. M. Wickens, occupied the chair.

Chairman,—

Gentlemen, I think it is time to proceed with the business of the evening. The first business will be the reading of the minutes of the previous meeting.

I might suggest, as you are all familiar with the nature of the minutes, that some one move to have them adopted as read.

Moved by Mr. Baldwin, seconded by Mr. Cole, that the minutes of the previous meeting be adopted as read. Carried.

Chairman,—

As we are now drawing towards the end of the year I may remark that we have had a fairly successful year, not quite perhaps as successful as it should have been, or as it might have been, but still on the whole the meetings have been fairly well attended and the discussions, while not taken part in by as many members as we would like, have been good. I hope the rest of the meetings to be held this year will be well attended and that we may have full discussions on the papers that are read. I may also point out that the gentlemen who have gone to the trouble of preparing papers to be read here have had considerable work and it is only courteous to them that the attendance should be as large as possible and the discussions freely indulged in. I may say that at the next meeting we are going to have a paper that will be the very best we have ever had. We will have moving pictures showing the different operations in the manufacture of steel tubing by Mr. Speller, of the National Tube Company. These pictures were taken right in the plant where this process is carried on; in the National Tube Company. They are sending us their special man to give us the moving picture show, and I believe, as I have said, that it will make the most interesting paper we have had this year. When the firm who are kind enough to provide us with this moving picture show, on a subject so interesting, are taking the trouble to send their man all the way from New York to demonstrate, I hope you will remember that; bear it well in mind. This is going to be a special feature; it is going to be something interesting, so be sure and come and bring a friend with you who will be interested in an attraction of this nature. Now, I must also mention that some of the members are behind in their subscriptions, and there is a large item outstanding against it. I have brought this to your attention as the year is drawing to a close and we want to end the year with our books in as clean shape as it is possible for us to do. I think that is all I have to say to you to-night, and it may be taken as the president's address to this meeting. I want my remarks to be taken as a spur to the individual members to work together to keep the meetings up to the high standard they have attained. We have with us Mr. Taylor, who will act as assistant secretary, and will make an accurate note of the proceedings of this meeting. We may now proceed to clean up the business, and then have the paper of the evening read with the discussion to follow.

Chairman,—

Has any gentleman present got anything to bring up that was not settled at our previous meeting, or any points to be discussed from the paper read at the last meeting?

Mr. Baldwin,—

There is one thing, Mr. Chairman, I might mention that has occurred to me and which I would like to draw to your attention, and to the attention of the members of this Club, and it is this: while it is not necessary that new members on joining should go through any form of ceremony, still, I think some times when we bring in a member that through his not being properly introduced he is not known to the members in general. Now, there are quite a number of members of this Club with whom I am in a way acquainted, but I do not know their names. Perhaps they have not been introduced at the meetings or had a chance to make their names known, and I think Mr. Chairman, it would be well to make those responsible for bringing new members into the Club, responsible also for seeing that they are introduced at the meeting. I therefore have pleasure in recommending that we work together to this end, and am taking this opportunity of introducing Mr. Fred G. Smith. I may mention that at some future meeting we are going to have Mr. Smith read a paper on the subject he is so familiar with and which he is so capable of handling. Mr. Smith is a structural engineer, and as this is a very important branch of practical engineering, and daily becoming more so, we will find it a very interesting paper. It is not only what you can get out of your work, but what you can put into it.

Moved by Mr. Baldwin, seconded by Mr. Cole, that all new members be introduced by the member that proposes them.

Chairman,—

You have heard the resolution, all in favour please signify by the usual sign. Carried.

Mr. Smith,—

Mr. Chairman, I am sure it is a great pleasure to me to become a member of this Society. I shall, however, have to take some of the remarks made with a grain of salt, but have great pleasure in becoming a member of your Club. (Applause).

Chairman,—

Is there any gentleman present who considers that the discussions on paper read at previous meeting was insufficient, and who would like to ask any further questions? None.

Is there any gentleman present who would like to bring up any questions of last meeting's business? None.

I shall now call on the acting secretary to give us the list of new members.

NEW MEMBERS.

Mr. A. W. Crouch, Vice-president and General Manager, Dearborn Chemical Co., Limited, Toronto.

Mr. N. V. F. Wilson, Secretary, Dearborn Chemical Co., Toronto.

Mr. Fred. G. Smith, Chief Draughtsman, Canadian Allis-Chalmers, Limited, Toronto.

MEMBERS PRESENT.

W. Austin	P. McCabe	J. M. Clements
J. Barker	John Dixon	Arth. C. Heathcote
Adam R. Taylor	Jas. Murdock	J. Macartney
T. B. Cole	S. L. Pearson	Geo. H. Boyd
James Reid	James Herriot	P. W. Shill
Geo. S. Powell	Thos. J. Walsh	Geo. A. Young
C. H. Stainton	J. W. McLintock	J. Grassick
E. Blackstone	Fred Slade	John Chambers
C. Russel	A. E. Price	Geo. Baldwin
Fred. G. Smith	J. McWater	A. M. Wickens

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F. Burrows
W. H. Alderson
H. Cowan
A. Hallamore
W. Kirkwood
W. McRae
J. Dodds
J. Duguid
J. Anderson
W. D. Cole
F. Hardisty
A. J. Lewkowictz
D. Campbell.
Chas. De Grouchy
W. C. Sealy
J. Bell
R. H. Fish
J. W. Jackson
G. McIntosh

Chairman,—

I will now ask Mr. P. McCabe to read his paper on "Compressed Air." The fact that compressed air is being used for so many purposes, and that the business is one capable of such expansion, will make the subject a very interesting one. I have much pleasure in calling on Mr. McCabe to read his paper. (Applause)

COMPRESSED AIR (HISTORICAL)

By P. McCABE, General Inspector of Compressed Air Plants, Toronto Railway Company.

Mr. Chairman and gentlemen,—I am going to read this paper to-night and see what you say when I am through.

The use of air in its lower condition of compression for power and for mechanical purposes has been known from the earliest ages, and antedates any knowledge we possess of the use of steam by many generations. The reduction of metals from their ores and the forging of the iron and steel brought the forge and the blast furnace, with the use of air, under pressure, into existence as mechanical appliances more than two thousand years before the Christian era.

The evidence of the use of the air blast under compression are plainly seen depicted on the sculptured walls of the structures of the oldest civilization, and are made still more manifest in its endurated paintings and in the legends of the early historians.

The old methods of compressed air production seem to have taken on a crude and nearly stationary form for at least two thousand years before, and for more than one thousand years after the Christian era, and in some parts of the world may be seen in operation to this day.

In China, India, Burmah, Africa, and Madagascar the primitive methods of compressing air are still in use. The air treading bags, the wooden cylinder and piston, and the Chinese wind box are the common devices for producing the air blast.

The properties exhibited by a partial vacuum must have been well known from five hundred to one thousand years before the Christian era, as illustrated in the use of the siphon and the atmospheric watering pots of the early Egyptians. Though the principle of the perfect vacuum is undoubtedly due to Torricelli, by his production of the mercurial vacuum about 1643 A.D., then its principles slumbered in its low pressure use for more than a thousand years, when the arrow discharged under air pressure by Cteribius, finally developed into the pneumatic gun of Maxim, in France, which was presented to Henry IV in 1600.

The water Trombe, or Tromp, for compressing air by a fall of water in a tube, used for blowing forges and other purposes, was known to Heron, and was mentioned by Pliny in his Natural History.

The principle of Heron's pneumatic fountain for raising water was carried out on a large and useful scale in the pneumatic pumping engine at the mines of Chemnitz, in Hungary, in 1755, which was erected by M. Hoell. There was probably first illustrated the refrigerating power of air when expanded from great pressures. In the lower chamber of this apparatus the discharge and its expansion with water produced pellets of ice.

The use of compressed air for submarine work was no doubt well known in the earliest ages. Aristotle, 350 B.C., describes a kettle in which divers supplied themselves with fresh air under water. The legend of the descension of Alexander the Great, to the bottom of the sea, in a vessel called a Cotympia with a glass window in it, is no doubt an allusion to the use of the diving bell. It was employed in Phonicica in the 320 B.C., and the use of glass was well known then.

Nothing further appears on record in regard to submarine work with a bell for more than fifteen hundred years, when mention of its use in Spain in 1538 is met with. Bacon describes it, in 1620, as a machine used to assist persons labouring under water upon wrecks, affording a reservoir of air into which they could take breath.

In 1715 Dr. Halley made the first contrivance for supplying the diving bell with fresh air by lowering air-filled barrels and discharging the air under the bell, letting out the foul air at the top through a cock, or of allowing of completely filling the space with air that was made unavailable heretofore, by the compression of air in the bell.

Dr. Halley suggested the present system of submarine armour by using a cap or portable helmet connected with a tube leading to the surface, through which fresh air was forced to the helmet for the needs of the diver.

Smeaton and Burnell, from 1779 on, improved on the use of the diving bell, making its operation continuous by a fresh supply of compressed air through tubes from pumps.

The submarine armour continued to be improved along the lines of its present form, for deep sea work, in which depths of one hundred and forty-eight feet have been attained, involving work under an air pressure of sixty-five pounds per square inch for several hours. It has been claimed that a depth of two hundred feet has been reached without serious results from the great pressure due to that depth.

The compressed air and vacuum pump was greatly improved by Otto VanGuerickue about 1650, and it has been claimed as his invention.

Savary increased the pressure of air for blast furnaces by the use of more substantial blowers, in the latter part of the seventeenth century.

Denys Papin was the first to propose and make, in 1653, an actual test of the transmission of power for a distance by compressed air. His early ideas being finally developed into more practicable shape, they resulted in his recommending the use of water power for compressing air. His system of an air pump driven by a water wheel, operating on air and water chambers, at a distance, was in the right direction, but failed in his practical operation by the elasticity of the air which he had intended to use as a long piston in transmitting power from an air working piston to distant water piston.

Papin first conceived the idea of the pneumatic tube for transmitting parcels by air pressure, thus antedating by more than two hundred years our pneumatic tube postal and package service and thus early opening for future advancement in the use of compressed air.

In 1757 Wilkinson, in England, patented a method of compressing air by the use of a column of water, effecting his object by means of a series of chambers, all water compressors, used one after another so as to keep up a regular pressure, thus in a crude way preceeding by a hundred years the water compressor of Somiliar at the Mont Pinis Tunnel.

The application of compressed air to practical uses and its transmission for power purposes seem to have commenced in the last years of the eighteenth century.

Professor St. Clair, of the Edinburgh University, in 1875, purposed attaching air bags to sunken vessels beneath the surface of the water and inflating them by air pumps. Its most successful trials were made in 1864, in raising a steamer sunk in Lake Boden, and in raising the vessels sunk at Sebastopol during the Crimean War.

Compressed air for driving vehicles seems to have had its birth with the beginning of the nineteenth century, in a patent to Medhurst, in England, August 2nd, 1800, for means for propelling carriages by compressed air from a reservoir.

COMPRESSED AIR FOR TRAMWAYS

The air brake seems to have first taken shape at this time, 1828, in Wright's patent with an eccentric on a wheel shaft, connected with a piston which was to be operated as a brake on down grades by pumping air into the air chambers, but it was not until 1869 that air brakes began to take a practical form under the patents of Westinghouse.

In 1828 Bompass, in England, built a compressed air locomotive. The first compound compression of air was probably suggested in the patent to William Mann in 1829. The use of two or more cylinders which was properly claimed not only to affect great economy in compressing air, but also to decrease the machinery strain and to admit of lighter construction of the compressor.

The use of compressed air machinery for quarrying, mining, and tunneling, and means of compressing air along economical lines have been greatly extended by the inventive genius of Burleigh, Ingersoll, Sargeant, Rand, Clayton, and others, who have contributed to and promoted the economy of practical operation in rock-boring machinery that has so greatly aided in excavating the vast system of railway tunnels of the United States, and in sinking and drifting in the mines of all countries during the past quarter of a century.

Every implement required in the generation of compressed air power and its uses has overflowed its earlier and narrow field of work and is now encompassing a wide area of usefulness in our workshops, factories, and in hundreds of industrial operations, transportation, railway appliances, refrigeration, even unto the painting of building and structural work, and the dusting of furniture, carpets, and clothing. The later development and actual application of compressed air at extremely high pressures and its economical use by reheating, derived from the persistent efforts of Mekarski, Beaumont, and others in Europe, and of Judson, Hoadley, Knight, and Hardie in the United States, have brought the use of compressed air to a new condition of application and a high pressure storage of 2,500 or more pounds per square inch in a condensed space of from 170 to 180 volumes to one volume. This allows for sufficient storage volume within the limit of passenger car and vehicle capacity for runs of reasonable distances.

The precise limit of the compressibility of air at ordinary temperatures is as yet an unknown quantity. It has been compressed to 14,000 pounds per square inch in experiments for blasting rock; and it has been asserted, and there seems to be no reason to doubt, that any pressure may be obtained within the limits of safety in the strength of metals to hold the pressure.

The assertion has been made by experimenters with high air pressures that 20,000 or more pounds per square inch may be available for special purposes; this is far below the explosive power of gunpowder.

The blasting effect of air at high pressure in coal mines was noted in a series of trials at Denton and Wigan, England, in 1877-79. During these trials a pressure of 14,200 pounds per square inch was attained by the comparatively crude methods of those days, as compared with powder. The trials were successful in the saving of time and in the health and safety of the men, but the cost of production exceeded that of explosives, and the scheme was abandoned.

The experiments in high air pressures conducted by Mr. Perkins, a noted engineer in England, and detailed in a paper read to the Royal Society, June 15th, 1826, are most interesting as demonstrating the liquefaction of air at ordinary temperature. Mr. Perkins used a cast steel pump, tested at 2,000 atmospheres, nearly 30,000 pounds per square inch, with water. Using the same pump for air, he observed the then curious phenomena that induced him to carry the compression of air to the highest limit possible. At 500 atmospheres, nearly 7,500 pounds, the air began to disappear, apparently by partial liquefaction; at 800 atmospheres, still further liquefaction was observed, at 1,000 atmospheres, 14,700 pounds, small globules of liquid air formed in the tube, and at 1,200 atmospheres, 17,640 pounds per square inch, a beautiful transparent liquid was seen in the glass compression tube.

Few attempts were made to liquefy air for many years succeeding Perkins' experiments, until about 1877, when Racul, Pictet, Cailletet, Dewar, Olzewski, and others followed in the line of producing liquid air by the cold or low temperature process and moderate compression system. Michael Faraday had been experimenting on the liquefaction of air and other gases since 1823, with indifferent results. More recently Professor Linde, in Germany, has by improved and larger appliances liquefied air in larger quantities.

Its practicability as a motive power has been doubtingly questioned, and even ridiculed, but the fact is in evidence that it has the qualifications of a power mover, and can be controlled for any required pressure. Its practicability and economy are now being tested; as a refrigerant its power is amazing.

The number of U. S. patents for compressed air devices and appliances has gradually increased during the past century, and is now upward of four thousand.

Air as it exists at and near the surface of the earth is a mechanical compound or mixture of several gases, principally nitrogen and oxygen.

A minute percentage of .002 to .005 of carbonic acid gas, a lesser amount of ammonia, and the newly discovered Argon, amounting to about one per cent. in volume, are always present in the atmosphere. At seldom less than 50 per cent. of saturation, at which point it holds .00044 of a pound of water per cubic foot of air at 62 degrees F., and at the point of saturation and temperature of 62 degrees F. it holds .00088 of a pound per cubic foot of air.

The expression of "Dry Air," used by our air compressor friends, is only relative, and air can only be considered dry when the amount of moisture is at less than 50 per cent. of saturation for any given temperature, the amount of moisture actually varies with the temperature to three times less at 32 degrees F. to three times more than the above figures at 92 degrees F.

The height of the atmosphere appears to have no determinate limit, but it gradually fades away in density and interplanetary space. At about 40 miles the refractive effect of twilight ceases, above that elevation the air is either too rare or too pure from foreign particles to send us any perceptible reflection or illumination.

There is abundant evidence, however, from the phenomena of meteors, that the atmosphere extends to a height of 100 miles at least, and it cannot be asserted positively that it has any well defined limit.

By virtue of the expansive force of the air, it might be supposed that the air in the upper atmosphere would expand indefinitely into the planetary space, but there are opposing forces that seem to limit its expansion; in proportion as the air expands in the upper regions of the atmosphere its expansive force is weakened and decreased by loss of heat, which partially counteracts its expansion, and with gravity probably holds its limit near the zone of absolute zero of temperature.

Below the level of the sea, as in the valley of the Dead Sea, and in the shafts and adits of deep mines, the density of the atmosphere increases in the same ratio as above the sea level for equal temperatures and humidity, such depths are indicated by the barometer under the same conditions as for the upper atmosphere.

The atmosphere obeys the law of compression and expansion when kept at a constant temperature, as found by Boyle and Mariotte, called Boyle's Law, or the first law of dynamics. By this law the density of air and the atmosphere under compression, whether from the gravity of its own weight or by artificial compression, is directly proportional to the pressure to which it is subjected, when its temperature is constant or at the same temperature throughout the change of volume.

It follows that when the height above the sea level increases by equal intervals and for equal temperatures the density of the air decreases in a geometrical ratio. Thus a cubic foot of air at sea level will become two cubic feet at about 18,000 feet above the sea, and four cubic feet at about 36,000 feet. This condition of tenuity of the atmosphere at great heights is shown in the scanty vegetation, and the difficulty of sustaining life in the attempts to climb to the dizzy altitudes of our highest mountains.

In the process of compressing air under the ordinary conditions of the atmosphere, it becomes heated by compression and on cooling in the compressed state becomes saturated by the narrowing limits of the moisture or water vapor held in the free air, and on further cooling the excess of moisture is set free as water in the reservoirs or pipes containing the compressed air.

As this would be a very long subject to write up. The moisture of air, and also very dry, although it is moisture, I will give just one example: 500 cubic feet per minute at atmospheric temperature at 67 degrees F. compressed to 75 pounds per square inch. Free air at 75 per cent. of saturation, which is about the mean condition of the atmosphere at or near sea level. Omitting the small increase in the ratio of saturation for the rise in temperature the mean between 62 degrees and 72 degrees in column three, page thirty-eight, Hiscox, to be .00525 x .75 for the percentage of saturation .0039375 x 500 cubic feet, 1.968 pounds of water condensed per minute. This is given only as an illustration to show the amount of water that will appear in reservoirs and pipe lines.

VACUUM

A vacuum is the zero of atmospheric pressure and is the beginning from which the absolute pressures start in many air problems; and, like the absolute zero of temperature, it is the point in the scale of pressure at which air expansion becomes infinite, and to which temperatures contract to the measure of interplanetary space.

This law of the compression and expansion of air and of other gases without change of temperature was first formulated by Boyle, in England, in 1662, and was further established by Mariotte, in France, in 1674.

It is called Boyle's Law and relates to the isothermal compression and expansion of air and other gases, and was written: When the temperature is kept constant the volume of a given gas varies inversely as its pressure or elastic force; that is to say, the product of pressure and volume is constant.

Having shown the relation of compression and expansion of air as a perfect gas under the Isothermic Law of Boyle, the action of heat as evolved in compression and eliminated in expansion of air becomes a most important factor in the practical work of compression, transmission, and utilization of air power.

The limiting point of heat by the compression of air is unknown, but is probably at the pressure of liquefaction, which has not yet been found with pressures up to 15,000 pounds per square inch and at temperatures raised in the experimental compressors and receivers. When air is once liquefied by pressure and artifical cold, it has been found to hold its liquid state at about 12,000 pounds pressure per square inch, at normal temperature, 60 degrees F.

Cooling from expansion of compressed air is inversely in the same ratio as from compression; or the temperature falls by the same scale that it rises.

As we have said above, the heat saturation point is probably at the pressure of liquefaction, so the cold extreme from expansion is probably at the absolute zero of expansion or perfect vacuum, which is now accepted as the zero of absolute temperature 460.66 degrees below the zero of the Fahrenheit scale. The difference of temperatures by compression for equal increments of pressure is much greater in the lower part of the compression scale than in the upper part; as for example, the increase of temperature from atmospheric pressure to one pound per square inch is 10 degrees F., while for an increase of one pound pressure from 99 to a 100 pounds is but 2.4 degrees F. The differences of temperature when plotted on a pressure diagram form a parabolic curve from its axis at absolute zero and terminating at infinite pressure and temperature, the conditions within the limits of practice indicate this curve, as also its inverse order in the expansion of compressed air.

Compression to the higher figures is not practicable by one stage compression, for at 1,000 pounds pressure the air rises to a full red heat 1,313 degrees F., and at 2,000 pounds to 1,709 degrees F. This is the theoretical temperature, but as much of the heat in the air would be absorbed by the compressor, it would soon become too hot for economical operation.

Supposing that no attempt whatever is made to keep the air cool, and that the air is to be compressed in a cylinder which will neither take up any of the heat of itself, nor allow any to pass out of the air while it is being compressed, this would be a case of adiabatic compression, and we should find that when the volume had been reduced to one half, the pressure would not be double only, as in the Isothermal case, but more than double, because of the heat generated during compression being still in the air or what comes to the same thing, when any given pressure is reached there would be a greater volume of air, owing to the heat in it, than had been found when compressing up to that same pressure had been isothermal.

The molecular theory helps us to understand why heat must be generated during both kinds of compression, for as soon as the piston begins to move it increases the energy of molecular vibration in the air contained by the cylinder, and is developed into activity and becomes sensible.

No compressor of the piston type of modern construction can produce the conditions required by the theoretically adiabatic or isothermal lines. The mean pressure practically is always between these two lines, and in most compressors nearer to the adiabatic than to the isothermal lines and also varies in the same compressor with the speed and the efficiency of the water jacket. In a high speed compressor the mean pressure nears the adiabatic line, while with a slow speed and rapid cold water circulation in the jacket it is possible to obtain a mean less than half the difference of the adiabatic and isothermal curves, time being a considerable element in fixing the curve of compression.

It is only with compressors of the old Dubois and Francois type with water injection and water filled clearance, and the hydraulic compressor of Sommeilles, that the isothermal line was nearly, or quite, reached; and later with the hydraulic pit compressors of the Frizell and Taylor type has it been possible to reach the full line of isothermal compression, and even under differences in temperature of the air and water, to produce a condition of compression of air and its delivery below the atmospheric temperature.

The great range of pressures through which compressed air is used, calls for pressures varying from one pound to 3,000 pounds, or more per square inch; but the greatest field of its work is found between 50 and 100 pounds gauge pressure. Even at 100 pounds the greatest economy of production is found in the two stage effect, which eliminates to a large degree the heat resisting power acquired during the second half of the piston stroke in a single stage compressor, for higher pressures the economy of two stage compression is largely increased up to 500 pounds and with three stage compression up to 1,000 pounds and with four stage up to 3,000.

The great heat generated by single compression to high pressures in Table XVI, pages 127, 128, 129, 130 is very lengthy, we will give just a few illustrations of the temperatures at various pressures. This heat is taken from air at absolute pressure, and 60 degrees F.

29.7	15	Lbs.	177.92	degrees F.
64.7	50	"	339.82	"
94.7	80	"	433.39	"
139.7	125	"	540.02	"
164.7	150	"	588.75	"
214.7	200	"	673.03	"
314.7	300	"	805.88	"

The effect of such great heat on the packing and lubricants of a compressor are apparent; hence the necessity for a two stage process with inter-cooling when compresing air to above one hundred pounds. The higher the temperature of air at the intake of the compressor, it will increase higher than that proportion to a given pressure as for instance, air admitted at 60 degrees F. compressed single stage to 300 pounds 805.88 degree F. Air admitted at 100 degrees F. to 300 pounds 910.00 degrees F., of course the absorption of heat by the cylinder walls modifies the temperature somewhat, but a fire pump shows that pressures from air at the ordinary temperature of a room will ignite combustibles at 300 pounds pressure.

The multi-stage compressors are built with water jackets, especially cylinder jackets, and though useful and perhaps indispensable, are not efficient in cooling, especially so in large compressors. The volume of air is so great in proportion to the surface exposed, and the time of compression so short, that little cooling takes place. Jacketed heads are useful auxiliaries in cooling, but it has become an accepted theory among engineers that compounding or stage compression is more fertile as a means of economy than any other system.

Two or four stage compressors are based on reduction to atmospheric temperature 60 degrees F. between stages, this is an important condition and in order to affect it much depends on the inter-cooler. In this device we have a case of jacket cooling. While cooling between stages we may split the air up into thin layers and thus cool it efficiently in a short time, a condition not possible during compression. This splitting up process should be done thoroughly and while it adds to the cost of the plant it pays in the end.

Referring to Hiscox we find that when air is compressed to 100 pounds in a single stage compressor without cooling the heat loss may be 38 per cent. This condition of course does not exist in practice except perhaps on high speed compressors, as there will be some absorption of heat by the exposed parts of the compressor. It is safe to say, however, that in large compressors that compress in a single stage to 100 pounds gauge pressure, the heat loss will be 30 per cent. This would be cut down one half by compounding or compressing in two stages and with three stages this loss is brought down to 8 per cent. theoretically and perhaps to three or four per cent. in practice as higher pressures are used the gain by compounding is greater.

The practical effect of compounding, however, does not result in any material economy, unless the air is cooled between the stages. Hot air in the cylinder of an air compressor means a reduction in the efficiency of the machine because there is not sufficient time during the stroke to cool thoroughly by any available means. Water jacketing, the generally accepted practice, does not effect thorough cooling.

The air in the cylinder is so large in volume that but a fraction of its surface is brought in contact with the jacketed parts.

Air is a bad conductor of heat and takes time to change its temperature. The piston, while pushing the air toward the head, rapidly drives it away from the jacketed surfaces, so that little or no cooling takes place. This is especially true of large cylinders, where the economy effected by water jackets is considerably less than in small cylinders.

Leaks through the valves or past the pistons will explain many indicator cards, and until something better than a water jacket is devised it is well to seek economy in air compression through compounding.

The Toronto Railway Company is a large user of compressed air and we believe we have the most efficient and most economical air brake system known. We have what is known as the storage system, at car barns and places where required, we have a compressed air plant of two or more, two stage, single acting, water jacketed compressors, which compress air to 315 pounds pressure. This air is stored in large reservoirs, 15′ x 3′, at that pressure, by an arrangement of piping from one receiver to the other. The air is cooled and practically all the moisture taken from it before it goes into the cars. On each car are two main reservoirs that would hold approximately 19 cubic feet, also a small reservoir called an auxiliary reservoir. Cars are charged to 300 pounds, or approximately that, and one charging is sufficient for eighty miles, city service, some two thousand stops. The air that is stored in the two main reservoirs is reduced to 40 pounds pressure through a reducing valve to an auxiliary reservoir and air is taken from that by motorman through motorman's valve, for braking service.

To give you an idea of the conomy of this system over others, as to the horse power, maintenance, etc., we have about 630 air brake cars, all double truck, heavy convertible type. In all our compressor plants, the total amount of power available is 411 horse power, as well as charging cars for the brake system, we clean all the upholstery of the system, and paint all our trucks with air from these plants. About the smallest individual compressor that could be used on this type of car is one of 14.5 cubic feet, to compress air with this unit to forty pounds pressure would take approximately 1½ horse power. As there are 630 cars this would take 995 horse power. As to the cost of maintenance or the upkeep of these small units, in an article taken from the *Electric Railway Journal*, the average taken from a great number of United States roads was $38 per car, for the year of 1912. This would be $23,940 for the 630 cars. The cost of our compressors would not be as much as one tenth of that. The consumption of oil on these small units is very much more especially after they are a year or so in use. We sometimes have a little trouble in our pipe lines, during the month of March, on account of frost, but on all lines a valve is placed so we can put mythelated spirits into lines, so that we have very little trouble from this source. On the individual pump system this is quite frequent, on account of the heat generated by compressing and the moisture in the air.

We use the best extra heavy lap welded galvanized pipe that we can get, so that we have no trouble from leaks in our pipe lines, as with 300 pounds pressure an infinitesimal hole in pipe would consume a great amount of power. We also have the best gate valves, extra heavy, procurable. We have a very fine check valve between compressors and reservoirs, and I must say that in the seven years we have had them I have yet to see them leak through. We clean all valves, intakes and discharge check valves about once a month, and I venture to say that it our plants were to be examined by an expert they would be found in the pink of condition.

Compressed air is claimed to be and is a safe power.

Compressed air is not inflammable, but during compression by mechanical means it is found advisable to use oil, and this oil, or the gases from it are the sources of combustion. In most cases firing may be traced to the use of poor oil, but in others too much oil sometimes caused ignition. It is a common mistake of engineers in charge of compressors to feed oil too rapidly to the cylinder. It is simply necessary to supply oil enough to keep the interior of the cylinder and the moving parts moistened. Where steam is used there is a tendency to cut away the oil, hence engineers grow accustomed to feeding a larger supply than is required in the air cylinder. There is nothing to cut or absorb the oil in the air end; in fact, it is only a considerable lapse of time that oil can get away when fed into the cylinder. There is no washing tendency as with steam, and a drop now and then is all that is required to keep the parts lubricated. Where too much oil is used there is a gradual accumulation of carbon which interferes with the free movement of the valves, and which chokes the passages, so that a high temperature may for a moment be formed and ignition follow. It is well to get the best oil and use but little of it.

There are cases where combustion has started from the introduction of coal oil or naphtha into the air cylinder for the purpose of cleaning the valves and cutting away the carbon deposits. Every engineer knows how easily he may clean his hands by washing them in coal oil and as this oil is usually available, men have been known to introduce it into the air cylinder through a squirt can at the inlet valve. This is a very effective way of cleaning valves and pipes, but it is a source of danger and should be absolutely forbidden.

High grade lubricating oils are carefully freed of all traces of benzine, naphtha, kerosene and other light and volatile distillates. The inflammability of the latter is so acute that it is a dangerous experiment to introduce anything of this kind into an air cylinder, and if any of our readers have had an explosion, in a case where the engineer uses kerosene, it may be traced to this source. Closed inlet passages leading to the air cylinder through which the free air is drawn from outside the building have many advantages, but one seldom thought of is that they interfere with the tendency of the engineer to squirt kerosene into the cylinder.

Ignition in compressed air discharge pipes and passages is not uncommon, at times this ignition is in the nature of an explosion. Two air receivers were blown up during the construction of the New York Aqueduct some years ago and did great damage. Other instances occur where ignition takes place near the air compressor the pipes becoming red hot at the joints. This ignition has been known to extend into the air receiver and in one instance the flames were carried down into the mine by the compressed air. About three years ago the writer saw a receiver blown up at the old Northern Elevator Dock. This compressor was only compressing air to 60 pounds pressure, and on my investigating it for my own benefit, I found that the air receiver had at one time held naphtha. It is plain that the cause of the explosion or ignition was an increase of temperature above the flash point of the naphtha in one case or of the oil used to lubricate the compressor in the other.

A thick or cheap grade of cylinder oil should never be used in an air compressor. Thin oil which has a nigh flash point, and which is as free from carbon as conditions of lubrication will admit is the best oil.

I have read of explosions where the flash point of the oil is 554 degrees F., ignition point 625 degrees F. and that the air was only compressed to about 60 pounds pressure guage pressure. If the temperature of the air before admission to the compressor is 60 degrees F. and it is compressed to 58.8 pounds pressure, the final temperature, where no cooling is used during compression, will be 369.4 degrees F., or a total increase of 309.4 degrees. If air admitted at 60 degrees F. is compressed without cooling to 73.5 pounds pressure the final temperature will be 414.5 degrees F., and the total increase of temperature 354.5 degrees F. Under such circumstances the question naturally arises: How is it possible when using oil with an ignition point of over 600 degrees to get an ignition, especially as water jackets and other methods of cooling are used which should reduce the final temperature? The figures are also based on dry air, which increase in temperature during compression to a greater degree than moist air, and it is known that air that is used in compressors is never very dry. The theoretical figures show that in order to get ignition with the oil mentioned the guage pressure should be about 200 pounds pressure where no cooling takes place. It is plain that there must be an-increase of temperature or ignition would not take place. This increase of temperature may result either from an increase of pressure which is not recorded on the guage, or there may be an increase of temperature without a corresponding increase of pressure. Take the first instance, and it is not difficult to understand that an air compressor might deposit carbon from the oil in the discharge passages, or discharge pipes, which in the course of time will accumulate and constrict the passages so that they do not freely pass the volume of air delivered by the compressor, hence a momentary increase of pressure might exist in the cylinder heads or in the discharge pipe which leads from the air cylinder to the receiver.

This momentary increase of pressure would surely carry with it an increase of temperature which might exceed the ignition point of the oil. A badly designed compressor with inefficient discharge passages might produce this trouble. Too small a discharge pipe or too many angles in discharge pipes might also tend to produce explosions, but we have known instances where ignition has occurred in a well designed system, hence we must look for other causes. The majority of cases may be traced to an increase of temperature without an increase of pressure, this increase of temperature can be excessive only when the temperature of the incoming air is excessive. A hot engine room from which air is drawn into the cylinder is a bad condition. It has been known of cases where the incoming air was drawn from the neighborhood of the boiler, the temperature being close to 150 degrees F., this means of course that if the total increase of temperature when air is compressed to 73.5 pounds pressure is 354.5 degrees F., the temperature of the initial air should be added to this figure and that the final temperature might be 505.5 degrees F. But we have known ignition to take place when the temperature of the incoming air was normal, when the discharge passages and pipes were free and of ample area, hence we must look for some other cause. The only explanation is that the temperature of the incoming air is made excessive by the sticking of one or more of the discharge valves, thus letting some of the hot compressed air back into the cylinder and thus raising the temperature before compression. When a piston of an air compressor has forced a volume of air through the discharge valves, and when this piston has its direction of movement reversed there will immediately be a tending of the air just compressed and discharged to return to the cylinder In this it is checked by the discharge valves, but through long and constant use the discharge valves become encrusted with carbon and are not free to move, hence there may be a moment when one of these valves stick, or it may not seat properly. in either case there will be some hot compressed air in the cylinder when the piston starts on its return stroke of compression the air may have lost its pressure, but not its temperature, and it is not difficult to understand a leaky discharge valve letting enough air back into the cylinder to increase its initial temperature to two or three hundred degrees. If so, and we are compressing air to 73.5 pounds pressure, we have say 300 degrees F. temperature, in free air before compression, and as the increase is 354.5 degrees F. the resulting temperature might be 654.5 degrees F. As a remedy it is best to examine and clean discharge valves and passages regularly, have a good check valve on pipe line from compressor to receiver, and on no account use a globe valve, as the passage through is not direct and causes friction and heat, use a good lubricating oil, free from carbon. Inter-cooler between air cylinders and after-coolers between final cylinder and receivers are also recommended. One of these after-coolers located in the discharge pipe will absolutely prevent the passage of flame and will insure the protection of mines against fire even though there be ignition at or near the air cylinder.

Chairman,—

We have heard the paper, gentlemen, and are now in a position to discuss it. Mr. McCabe has had such experience that he can answer almost any question you can put to him in connection with compressed air, and he has placed himself in the hands of the members. If there is any gentleman who wants further enlightment I am sure Mr. McCabe will be only too pleased to answer any questions put to him. I must ask the gentlemen who are going to speak to be kind enough to announce their names in order that what they have to say may appear opposite their names in the book. And now, gentlemen, there are some of you, no doubt, who would like to ask a question.

Mr. Baldwin,—

A couple of days ago I received from Mr. Worth a copy of the paper to be read here to-night but the paper which I received does not include the whole of the paper that was read by our friend Mr. McCabe here to-night. In the first place the historical part of his paper, which is the first part, does not allow of anybody discussing it so far as I can see, for I have gone through it pretty thoroughly and there are very few points indeed, but what are covered in that paper. I may say the same applies to the latter half of the paper, a copy of which I did not receive and did not know anything about until I heard it read to-night. But it is a well known fact that Mr. McCabe understands compressed air from the top of the tall chimney down to the ground. There is, however, one thing I would like to ask Mr. McCabe, and that is this: Would he be kind enough to draw us a rough sketch on that blackboard of one of the compressing stations. Now, the majority of people when they get on a car know that the brakes are controlled by the air, but do not know how the air is got into the car, nor how it is compressed, and I am sure Mr. McCabe is quite capable of doing that, and it would give us a rough idea of how the air is compressed and of how it gets from the reservoirs or storage tanks into the cars.

Mr. McCabe,—

Mr. Chariman, I am not a draughtsman; that requires a draughtsman.

Chairman,—

Then perhaps Mr. McCabe you will explain it for us.

Mr. McCabe,—

Yes, I will explain anything but I am not a draughtsman, and could not make a satisfactory sketch on the blackboard.

Mr. Baldwin,—

I merely thought a rough sketch would be the most satisfactory method of explanation, and I feel sure Mr. McCabe is quite capable of it.

Mr. McCabe,—

I will be pleased to explain anything, but as to making a sketch on the blackboard, that is quite out of my line.

Mr. Grassick,—

I would like to ask Mr. McCabe how the process of intercooling or cooling of air after being compressed is carried out?

Mr. McCabe,—

When air is compressed two or more stages, it passes through what is called an intercooler. This intercooler is a large chamber in which the heated air, after being compressed, passes through. In this chamber or intercooler are a great number of small tubes, so arranged at the heads that cold water flows through them. The hot air coming into contact with the cold tubes on the outside of them is split up and finally emerges from the outlet end cooled back to say, 60 degrees Fahr., as before it was compressed. There are some fifty different makers, making all kinds of intercoolers. There are a hundred and one different styles, and we have some intercoolers with half inch tubes, which allow water to pass through and the air passing over these tubes is split up into small particles—that is what is meant by splitting up the air.

Compressed air is compressed in some places and sold in the same way as electricity. It is sold by meters, but in this country and in the United States I do not think the proper value is given to compressed air; they do not value the compressor as highly as they should; they run it indefinitely year in and year out, and that accounts for practically the losses that are claimed from its use instead of other powers.

Mr. Grassick,—

Can the air be measured satisfactorily?

Mr. McCabe, —

Yes, the air can be measured by a meter the same as gas, or by taking the cubical contents of a reservoir and by multiplying the number of volumes that it holds at a given pressure and temperature.

Mr. Baldwin,—

Is your plant driven by electricity or steam?

Mr. McCabe,—

We drive them all by electricity.

Mr. Baldwin,—

I think you used to drive them by steam.

Mr. McCabe,—

No, we never did.

Mr. Baldwin,—

Could you give us the difference in cost Mr. McCabe?

Mr. McCabe,—

No, I could never tell you that.

Mr. Baldwin,—

Do you think steam is cheaper in most cases?

Mr. McCabe,—

No, but perhaps it is in some cases; I know it takes approximately two horse power of steam to make one horse power of air. Air is very costly to compress; it is more costly than steam and more costly than electricity, but it has certain advantages in being able to be used where steam could not be used, and in cases also where it can be used and where it would not pay to use electricity. For instance, it would not pay to use an electric brake, and there are hundreds of instances where air is in its proper place as the power and can be used for less money than either steam or electricity. A great deal depends on the style and design of the compressor, as the differences of compressing air are so varied, and the different methods employed for cooling before storing. I read an account not long ago about an engineer who was called upon to inspect some large compressors at about 4,000 cubic feet displacement, but the machines had not received the attention that the manufacturers or owners of the plant thought they should receive, and so they sent to a college attached to one of the large universities for this engineer. He pointed out a number of irregularities. I think there were four compressors altogether, and the highest efficiency was 47% which indicated simply that the machines were not properly looked after or kept up.

Mr. Cole,—

I would like to ask Mr. McCabe if by compressing air up to 250 pounds you would have any difficulty with water; if you do not get any water up to that pressure how do you account for water?

Mr. McCabe,—

We get water on account of the moisture in the air hot. Our system is furnished by three, four and five large reservoirs 15 feet long by 3 feet in diameter. The air that is compressed goes into the first reservoir, and then by an arrangement of pipes from one reservoir to another and is allowed to cool before finally going into cars. The air goes into the first reservoir like saturated fog or very light steam. By passing through the pipe line and through the tanks it gradually gets cooler. It passes from one tank to another. At the first tank you might get a gallon of water from it; at the third tank a pint of water might possibly be taken from it, and at the fourth tank very little indeed, perhaps only a gallon in two weeks. So that is how the moisture is taken out of the air before passing into the pipe line.

Chairman,—

Has any gentleman any further questions to ask?

Mr. Grassick,—

I am very much interested in air from suction; that is compressed air, I suppose. I have a vacuum cleaner that is worked by suction, and I suppose that is an application of the compressed air principle. I have a machine now that works at 10,000 revolutions per minute. It has been figured out carefully and is given as correct. How would you figure that out—have you any idea?

Mr. McCabe,—

That would be figured out by the manufacturers.

Mr. Grassick,—

Could you figure it out?

Mr. McCabe,—

It makes 10,000 revolutions per minute?

Mr. Grassick,—

That is according to the plans of the manufacturers.

Mr. McCabe,—

That would depend on the size of the fan to give the amount of feet displacement at the fan. It is a fan for displacement.

Mr. Grassick,—

Would there be a tendency for the fan to heat?

Mr. McCabe,—

No.

Mr. Grassick,—

Yes, it is 40 cubic feet displacement at the nozzle per minute.

Mr. Taylor,—

There is one thing Mr. McCabe I would like to ask. You say at sea level the air at a certain temperature contains so much moisture. Am I right?

Mr. McCabe,—

Yes.

Mr. Taylor,—

Then, if the temperature of that air were lowered there would be less moisture.

Mr. McCabe,—

Yes.

Mr. Taylor,—

The cooler the air the less moisture. A greater percentage of moisture at a higher temperature. Now, you are compressing air to a high temperature, therefore you would think it would contain more moisture; is that right?

Mr. McCabe,—

No that is not right. We have air at say 60 degrees Fahr., there is a certain amount of moisture in that say 50%, now we could not get any more moisture in that air by compressing it.

Mr. Taylor,—

No, you say you take it out. In what way?

Mr. McCabe,—

It is taken out in a way, but during the act of compressing, the moisture is still in the air.

Mr. Taylor,—

In the act of compressing, the moisture is still in the air?

Mr. McCabe,—

Yes, and the compressors may take some of that out. The air could not contain more than 50% of moisture, and that will pass through the reservoirs as fog, and after passing through the intercoolers, back to the same condition it came from, the moisture will drop into the pipe line or reservoir the same as water, and the air will be practically dry.

Mr. Taylor,—

Supposing the air to be at a temperature of 40 degrees, and it held, say 60% of moisture, you compress that air with 60% of moisture, and the air is heated to 300 degrees while containing that moisture, after you cool that air down to 40 degrees again where do you get the moisture that is at the bottom of the tank?

Mr. McCabe,—

The moisture will be practically all in the reservoirs.

Mr. Taylor,—

Then the moisture cannot be in the air?

Mr. McCabe, —

No, not at that time.

Mr. Taylor,—

What I am trying to get at is this: the air will hold in suspension 50% of moisture, until when you compress the air, and you cool it back to the same temperature you started from, you have not lowered the temperature proper.

Mr. McCabe,—

You mean you are bringing it back to a temperature of 40 degrees Fahr. with 50% of moisture.

Mr. Taylor,—

Yes. You compress that and by the compression of that air you raise the temperature 300 degrees; now, when you cool that compressed air back to 40 degrees the moisture is at the bottom of the tank.

Mr. McCabe,—

The moisture is at the bottom of the tank.

Mr. Taylor,—

That is really not what I am trying to get at. Does compressed air contain 50% of moisture the same as before entering the compressor.

Mr. McCabe,—

Oh no! the compressed air is absolutely dry.

Mr. Taylor,—

Take the air at a temperature of 40, and suppose the compressor shows 60% of moisture; then expand the air back again you would not get the moisture at the bottom of your tank; therefore the compressed air holds moisture.

Mr. McCabe,—

No it will not hold moisture.

Mr. Taylor,—

Unless I have misunderstood the explanation it must.

Mr. McCabe,—

No it will not.

Mr. Taylor,—

Thank you.

Mr. McCabe,—

The moisture is extracted from the air and lays at the bottom of the air reservoir. Of course, with a great inrush of cool air a certain amount of moisture would go out with the escaping air that was confined in the pipe lines. But the compressed air, if it was discharged after being compressed then moisture would be in the air, but the moisture is in the air in the first place, as I have said, like a saturated fog, but if it is allowed to cool it comes back to atmospheric conditions again then it is absolutely dry.

Mr. Grassick,—

What is the liquifying point of a compressor plant? When does it liquify?

Mr. McCabe,—

I have never had any experience in liquifying air; some say it liquifies at 20,000 pounds.

Mr. Grassick,—

Is it possible to convert that water into liquified air?

Mr. McCabe,—

Well, at one time the moisture that comes out of a reservoir is like milk provided there is not too much oil or dirt. Some time ago an old boilermaker, I think he was at the Canada Foundry, asked me, "What do you do with that water?" He understood quite a lot about compressed air. He said, "The finest thing in the world for rheumatism (laughter); so a great many men for a number of years on the Toronto Street Railway have taken that water, and I have never heard any person say that it did not do them any good. They take it out of the tank, and after a while it becomes clear and they bathe the parts afflicted. Although I never, fortunately, suffered from rheumatism, I have no doubt it is a good thing. You have a close approach to liquified air for it has had a good chance to liquify at 315 pounds pressure.

Mr. Baldwin,—

As you know, we have a large compressor plant at the Canada Foundry. You stated that the moisture was left in the first, second and third tank in your case.

Mr. McCabe,—

Yes. Well, ours is the same, or a very similar plant.

Mr. Baldwin,—

Well, in the bridge shop, and boiler shop, there are 20, 30 or 40 riveting hammers and chippers. Every once in a while you will see the fellow that is holding the gun get splashed in the face with water; can you tell me what brings that water up to the hammers?

Mr. McCabe,—

The cause of that would be insufficient storage capacity for the amount of air you are receiving or displacing or the discharge reservoirs are not sufficiently large enough to allow that air to be cooled properly, but it is mostly caused through insufficient storage. Not sufficient storage in them to allow air to cool properly before using and that the air may not circulate throughout and so hot air may pass through the top, and come out first.

Mr. Baldwin,—

Is there any danger from ignition from the heat of the air?

Mr. McCabe,—

There is. There is a great danger in the use of poor oil or lubricants, or in the use of too much.

Mr. Cole,—

The only danger seems to be from the gasefying of the oil. Is there not now some substitute for oil?

Mr. McCabe,—

As to that I don't know.

Mr. Cole,—

Graphite is sometimes used I think.

Mr. McCabe,—

Graphite is a very bad thing to put into an air compressor; it is compressed under compression with air, and not by expansion as with steam. I have seen graphite gathered in an air cylinder like little balls or pin heads.

Mr. Cole,—

I have had no experience, but I understand Messrs. Dixon & Co. issue a pamphlet dealing with the question.

Mr. McCabe,—

I do not know; I could not tell you that. They may, of course, have discovered something, but I know nothing about it. We use a very high grade of oil—80 cents a gallon is paid for it—that is pretty costly when you buy it by the barrel but we use it very sparingly.

Mr. Fletcher,—

Perhaps, Mr. McCabe can enlighten us as to whether ignition could take place in connection with a Drexel engine. I understand you have compressed air in the boiler?

Mr. McCabe,—

No, the compressed air there is used in addition to the Drexel engine. Instead of the oil exploding from ignition the compressed air is used to make it explode at a higher ignition than it would do under ordinary conditions; that is what I understand; the compressed air being heated the ignition is higher than what it would be under atmospheric conditions, I think they say about 400 pounds pressure would bring that air up to about 1,000 degrees Fahr.

Mr. Baldwin,—

I would like to know, Mr. McCabe, if it is possible to deliver compressed air very far?

Mr. McCabe,—

Oh yes! Compressed air is carried twelve and fourteen miles from the power house.

Mr. Baldwin,—

Well, I do not know much about it, but how far could you take it if you had good protection; has the friction to be taken into account when the air is passing through the pipe lines, and does the air get colder in temperature?

Mr. McCabe,—

They take reheaters so as to get more expansion; they reheat the air and it expands.

Mr. Grassick,—

What would be the advantage of reheating it?

Mr. McCabe,—

To get expansion in the use of same for drills, etc.

Mr. Cole,—

The paper that we have had this evening has been a most satisfactory one, and I have listened to it with a great deal of pleasure, as I am sure all the other members present have, and I feel that Mr. McCabe is deserving of a hearty vote of thanks from all.

Mr. Baldwin,—

I am sure I quite agree with Mr. Cole in moving for a vote of thanks to Mr. McCabe, and I feel that we all do—(Loud applause). Moved by Mr. Cole, seconded by Mr. Baldwin, that this meeting tenders to Mr. McCabe a hearty vote of thanks for the highly interesting paper on Compressed Air, that he has read before the Club this evening.

Chairman,—

I said when I got up that we had kept the best papers to the last of the year, and I think in that I made no mistake. The paper read before us to-night is one of the very best we have ever had. I think, perhaps, it is well that we should have kept the best of the papers to the last of the year and I have the pleasure of tendering to you, Mr. McCabe, a hearty vote of thanks on behalf of all the members present for your very excellent paper.

Mr. Baldwin,—

There is one thing more I wish to say, Mr. Chairman, in regard to a smoker we decided to have before Christmas, before your term of office expires.

Chairman,—

Yes, but I believe we have not as yet decided to hold a concert or anything of that character.

Mr. Baldwin,—

No, the suggestion did not run like that.

Chairman,—

We have not had a meeting of the executive committee since last regular meeting, and consequently nothing has been done along those lines.

Mr. Baldwin,—

Yes, Mr. Chairman, but the time has come I think for something of that nature. There is nothing like concerts, entertainments, and smokers to keep the members together. I thought perhaps you had that idea up your sleeve just now when you said we were keeping the best things to the last.

Chairman,—

Before we adjourn I would like the executive to wait a minute or two to discuss some matters.

Mr. Baldwin,—

Before closing I would like to say that I understand from the acting secretary, that Mr. Worth has lost his father, and although he was a very old gentleman the fact still remains that Mr. Worth and his family are bereaved, and I would therefore suggest that someone be appointed to draft a letter of condolence to Mr. Worth and his family.

Mr. Cole,—

If that is a motion I have much pleasure in seconding it.

Moved by Mr. Baldwin, seconded by Mr. Cole, that a letter of condolence be drafted and forwarded to Mr. Worth, whose father died suddenly.

Committee: Mr. Baldwin, Mr. Walsh, Mr. Herriot.

Chairman,—

I would suggest that some one move the adjournment of the meeting.

Mr. Baldwin,—

You seem anxious to get rid of us, Mr. Chairman.

On the motion to adjourn being carried the meeting adjourned at 10 o'clock p.m.