Indeed we can ~~today~~ reach in our laboratories temperatures very much lower than ~~[illegible]~~ necessary for this purpose.

The story of the production of low temperatures starts with a well-known experiment made by Faraday nearly a century ago. ~~The~~ An account ~~record~~ of this experiment has been left ~~is given~~ by Dr Paris. Happening to call at the laboratory one evening, Dr Paris ~~relates~~ found Faraday engaged in heating ~~I~~ some chlorine hydrate in one limb of an inverted U-tube, the other limb of which was

Kept ~~cool~~ cold under a freezing mixture. Dr Paris who was watching the experiment, saw some oily matter sticking to ~~the~~ the inside walls of the tube, and he rallied Faraday – I am using his own expression – on the carelessness of using soiled tubes. ~~D~~ The next morning, Dr Paris relates, he ~~received~~ received a laconic note from Faraday "Dear Sir, The oil you noticed yesterday turns out to be liquid chlorine."

~~On chlorine hydrate on heating evolves chlorine gas, an whi~~

The chlorine gas evolved from the heated hydrate had developed a high ~~pressure~~ inside the sealed tube, and under this pressure had condensed into an oily liquid.

Very soon ~~after~~ other ~~the~~ gases, like sulphur di oxide, ammonia and carbon di oxide, were also liquefied under ~~pressure~~ in the same manner, and in ~~[illegible]~~ large quantities.

You may now ask me what is the connection between the liquefaction of gases at high pressures and the production of low temperatures. If one of the tubes containing a liquefied gas at high pressure is cut open, the gas will naturally ~~rush~~ escape with violence, and part of the liquid will evaporate, and as a result of this evaporation the liquid that is left over will cool down considerably. For example liquid carbon di oxide, made to evaporate rapidly, may cool down sufficiently to form carbon di oxide snow, or dry ice as it is popularly called, with which many of you may be familiar. It is sold

? by the ice cream vendors in some of our large cities, and when dropped into water makes cool aerated water

Faraday found that by mixing ~~so~~ dry ice with ether, a liquid is obtained which boils at −78°C. By connecting it to a pump and allowing it to evaporate rapidly, ~~and~~ at a low pressure, Faraday found ~~that~~ he could reach as low as −100°C, which, a century ago, must have been very low temperature indeed.

Though many of the known gases were liquefied in this manner, some of the common ones ~~[illegible]~~ like oxygen, nitrogen and hydrogen resisted all attempts at liquefaction. ~~If~~ Even ~~at~~ with the lowest temperature then attainable, namely −100°C, and a pressure of 3000 atmospheres, i.e. about 45,000 lbs ~~[illegible]~~ to the square inch, it was not possible to liquefy them. For this reason they came to be ~~called~~ known as the permanent gases.

That ~~it was not~~ these gases could not be liquefied under the above conditions is not surprising, since we know now that for any given gas there is a certain critical temperature above which it is not possible to liquefy the gas, however high the pressure may be. For ~~oxyg~~ ~~the so called permanent gases,~~ oxygen, nitrogen and hydrogen the critical temperature is much below −100°C.

Till the late eighties of the last century, those so called permanent gases ~~were~~ kept up the reputation of their names, and remained unliquefied. In the Dec. of 1877, the liquefaction of one of them, namely Oxygen, was announced in a dramatic manner, ~~by and at~~ and at about the same time ~~and by~~ ~~at nearly the~~ within a few ~~days of each other~~ by two physicists, namely Cailletet working in Paris and Pictet working in Geneva. Cailletet's discovery is due to what is sometimes described as an accident. He was compressing acetylene gas in a glass tube with a powerful hydraulic press, but had forgotten to close the exit valve of the tube. The pressure developed in the gas was, ~~[illegible]~~ thus ~~suddenly~~ relaxed, and the ~~gas expansion~~ due to the sudden expansion of the gas which followed the gas had cooled so far as to ~~[illegible]~~ form a dense mist of the liquid. Cailletet realised the significance of the ~~a~~ observation, repeated the experiment with ~~compressed~~ oxygen at low temperatures, with a similar result. ~~The result was~~

In Pictet's experiment also ~~it [illegible]~~ the liquefaction of Oxygen must have occurred as a dense mist.

Though these experiments demonstrated the possibility of liquefying oxygen, ~~they ~~could~~ can not ~~not~~ be regarded as having solved the problem of liquefaction, since the mist of liquid evaporated away ~~rapidly~~ immediately. The production of liquid oxygen in~~

~~quantities large enough to be liquid and experimented on was evaporated, for the purpose~~

~~are not~~

the liquid oxygen ~~are~~ obtained in the expts was ~~only~~ merely in the form of a mist, which evaporated away almost immediately.

The production of ~~ox~~ liquid oxygen in ~~sufficient~~ quantities ~~large enough~~ sufficient to be handled and experimented on was ~~soon~~ made possible (a little later) by the two Polish physicists Wroblewski and Olszewski, who used ~~by~~ what is generally described as the cascade method. The ~~essential success of this method in his its application to~~ method was originally suggested by Pictet, and its successful application by the Polish physicists to the liquefaction of oxygen consists essentially in their ~~realize~~ finding a suitable substance namely ethylene used as an intermediate substance for cooling. This gas can be which can be ~~liquefied~~ liquefied ~~under pressure~~ (easily) at the ~~at~~ temperature obtainable with ~~liquid rapidly eva~~ ~~carbon~~ liquid carbon dioxide. Now Ethylene liquid ~~easily~~ when it is allowed to evaporate~~d~~ rapidly can give a temperature, which ~~below~~ below than ~~the~~ the critical temperature of Oxygen. ~~Oxygen~~ ~~can therefore be liquid~~ At this low temperature Oxygen can be liquefied easily under pressure.

Oxygen boils at atm. press. at − 183° C, and when allowed to evaporate rapidly at low pressures, can give us temperatures of the order of − 210 or even − 215. C. This temperature however, is not sufficiently low for the liquefaction of hydrogen.

I should mention here another method, based on the ~~that many of these~~ ~~gas, when allowed to escape~~ observation, made originally by Kelvin and Joule, that many gases, when allowed to ~~evapor~~ escape through an orifice cool slightly. ~~By allowing~~ ~~the slightly cooler~~ The cooler gas ~~that~~ escapes can be made to ~~cool~~ cool the fresh gas ~~coming~~ ~~in~~ coming in, and in this way by ~~a successive~~ ~~of small~~ successive steps, the gas may be cooled sufficiently to issue as a ~~li~~ jet of liquid. The method is extremely useful ~~for~~ for the production of liquid oxygen, or nitrogen, or air in large quantities, and is more or less generally used ~~in industrial~~ ~~for this gas~~ for the preparation ~~fact.~~ of ~~this liquid~~ these liquids on an industrial scale. ~~Using~~ ~~the cooling~~ ~~Using~~

~~Liquid Liquid Oxyg~~

~~With~~ Using liquid oxygen, ~~a similar regenerative one for~~ precooling, hydrogen can be liquefied in the same manner, and hence also helium.

The last liquid boils at ~~4~~ $-269°$ C, and by connecting it up to an ordinary ~~[illegible] pump~~ air pump temps in the neighbourhood of $-272°$ C can be readily obtained.

273.1
4.2
268.9

~~We thus have~~ ~~Thus we~~ With the help of these liquids, it is thus possible to obtain in the laboratory any temperature from ~~[illegible]~~ that of the room to about $-272°$ C.

I may be permitted here a digression
~~Attention was~~
It is a historical fact that man
~~produ~~ learnt to produce ~~very~~
high temperatures high enough to
melt ~~glasses works many metals~~ melt many metals, ~~thousand~~ several
thousand years ago, whereas the
production of ~~cold is very recent~~
~~very~~ ~~an~~ any considerable degree of
cold was ~~is~~ ~~a~~ a ~~[illegible]~~ very recent
achievement, ~~Even today it is~~
~~much easier to ... and had to~~
~~await a~~ and was made possible
only by a recognition of the general
thermodynamic principles ~~of the~~ underlying the production
of cold. This (as Professor Simon pointed out) ~~result~~ fact really is
very significant. ~~Because~~ Accordingly
to modern ideas ~~concer~~ ~~regarding~~

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The heat of a body consists
in the ~~[illegible]~~ disorderly motions of its
ultimate particles, namely the molecules.
Heating a ~~gas~~ body therefore means ~~[illegible]~~
increasing ~~the~~ the intensity of these
~~disorderly movements. Similarly~~ ~~[illegible]~~
~~cool~~ thermal agitations, and in
particular ~~the~~ increasing the amount
of internal disorder present in the
body. Similarly ~~the production~~ cooling
a body ~~means~~ implies not only
a diminution of the thermal
agitations, but ~~the~~ a diminution
of the internal disorder also, i.e.
the production of some kind of
order in it. In Physics at any rate, it
~~is much easier to produce disorder~~
~~than to produce or~~ is much more
difficult to produce order than to