Henderson : How long does the Ecole Polytechnique group take to fill the present chamber (BP2) and to get it uniform ?

Bloch : To fill only, about half an hour. But if you consider the complete preparation of the chamber, starting from the beginning it takes 8 to 9 hours to have it ready for operation, including about 6 hours for heating.

Hahn : How do you measure the composition of the mixture ? Do you measure the density ?

Bloch : At present, with a ruler fixed at the chamber we just measure, to within 1 mm, the heights of the volumes occupied by the liquids. Accurate measurement of the composition will be made by spectroscopy by the "Institut du Pétrole".

Lagarrigue : We cannot measure the density because we would have to measure it during the expansion, when the liquid is in a metastable condition. We intend to check the density by looking for scattering of π-mesons on protons. If the scattering occurs in a plane parallel or perpendicular to the front glass it is possible to measure the density and the index of refraction.

5.2. B.Hahn - Survey of some bubble chamber liquids.

Among the liquids for bubble chambers there are two extremes in application:

1. Liquid hydrogen, which offers the possibility of doing experiments on free protons.
2. Liquids with high Z, which have high density and short radiation length.

I would like to give the operating conditions of several liquids with high Z that we have tried in our experimental chamber. The same liquids we might try now in our present chamber, which is larger.

Figure 11 summarises the operating conditions os such liquids. The operating pressure ($P_{operating}$) in atmospheres is plotted as a function of the operating temperature ($T_{operating}$) in degrees centigrades. The operating pressure goes up to about 30 atm (except for substances like water, for instance, for which it goes to 180 atm, but then it is not interesting). In Figure 11 the operating points are represented by the dots. The length of the vertical line which are drawn from the dot upwards represent approximately the radiation length of the liquid in a scale 1 : 10.

Dr. Kalmus already told us about several liquids and mixtures, and there are also gas-liquid mixtures about which Dr. Gigli will talk later.

Tellurium hexafluoride. A few weeks ago we have tried this liquid which has very convenient operating conditions: operating temperature of 45°C and equilibrium pressure at the operating point of only 15 atm. We estimated the density in 1.8 g/cm^3. The radiation length is about 7 cm, i.e., about twice that of tungsten hexafluoride.

Sulphur hexafluoride. Also seems to be a good liquid. Its operating temperature is 15°C and the equilibrium pressure at the operating point is 19 atm. Radiation length about twice as large as that of tellurium hexafluoride. It is a safe liquid and easy to handle. It works in a dirty chamber, as do the other liquids of Figure 11. In a clean chamber the values given in Figure 11 might go down by about 20 or 30 o/o.

Saturated fluoro-carbons. Some time ago we started a systematic search for liquids which are not only suitable for experiments, but rather that are very safe to handle and which give reliable chambers. We found that liquids with very nice operating conditions are the saturated fluoro-carbons, which are also represented in Figure 11. We see that the operating point depends on the size of the molecule. The Figure shows that the operating pressure is about half that of the hydrocarbons. Most of these liquids are stable, non-corrosive, non-toxic, do not burn and are easy to handle. The density is about 1.4 g/cm^3 and the radiation length of the order of 25 to 30 cm.

I think that fluoro-carbons chamber of about 20 cm might be very useful for surveying beams of large accelerators, because they are easy to handle. We have a 16 cm chamber which can be assembled in a few hours by about two people. They can also be used for high energy experiments when free protons are not required or when a medium radiation length is wanted.

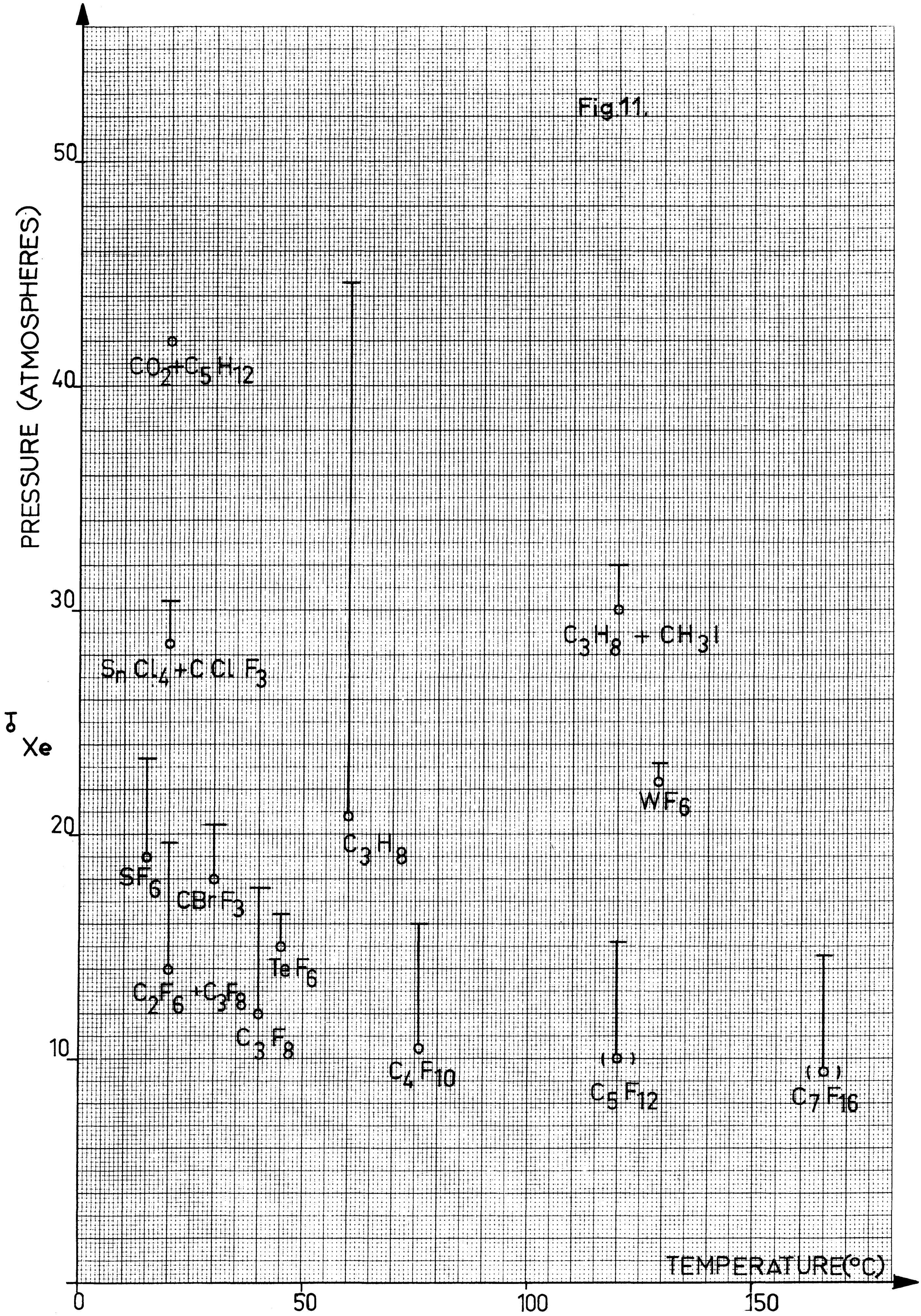

Fig.11.
PRESSURE (ATMOSPHERES)
TEMPERATURE(°C)
50
40
30
20
10
0
50
100
150
$CO_2+C_5H_{12}$
$SnCl_4+CClF_3$
Xe
$C_3H_8+CH_3I$
WF_6
C_3H_8
SF_6
$CBrF_3$
TeF_6
$C_2F_6+C_3F_8$
C_3F_8
C_4F_{10}
C_5F_{12}
C_7F_{16}

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DISCUSSION.

Lagarrigue : What is the corrosion property of tellurium hexafluoride ?

Hahn : I cannot yet make any definite statement about corrosion. We have this liquid in our experimental chamber which has 6 cm diameter, is made of brass, glass windows and rubber gaskets, for a few days without noticing any inconvenient effects. We also had some gas going out into the room and we did not notice any corrosion of metals. It is known that the sulphur hexafluoride is an extremely stable molecule because the fluorine atoms are arranged in a cycle around the sulfur. This substance has to be heated to red heat and with a spark of about 10 kilo-volts it is very difficult to get it into reaction. With increasing of atomic number Z these properties become worse. You know the properties of tungsten hexafluoride for instance, but it seems that tellurium hexafluoride is somewhere between the sulphur hexafluoride and tungsten hexafluoride with respect to its chemical reactivity. We have to do more experiments with this substance, but it really looks promising.

Lagarrigue : What is the price ?

Hahn : About 10 dollars per pound, and it is available in the U.S.A.

Loria : Is it toxic ?

Hahn : Probably it is a little but less than the tungsten hexafluoride, but we have not much experience... During the emptying of our chamber, one of our colleagues received some tellurium hexa-fluoride directly on his face; he had some cough and pains on his lungs for two days, but he got well again.

Kalmus : I think that the danger with tungsten hexafluoride is that if water is present, hydrogen fluoride is formed. The tungsten has more a corrosive action than a poisoning action.

Bloch : Is sulphurhexafluoride commercially available ?

Hahn : Yes. It is used in Van de Graaff accelerators and it is cheap.

Henderson : What is the lower pressure of the expanded chamber with SF_6 ?

Hahn : Our experience is that with dirty chambers of size of about 20 cm, it is about half that of the equilibrium pressure.

Salmoron : Have the radiation lengths which you quoted been calculated by using the same expression as Kalmus ?

Hahn : I used the Z^2 expression which gives for propane 112 cm, for the fluor carbons 25 to 28 cm, for tellurium hexafluoride 7 cm and for xenon 3.5 cm .

5.3. A. Gigli - Further developments in gas bubble chamber technique.

My purpose in this communication is to report on the basic characteristics of the gas-bubble chamber [1),2)].

The work was and still is carried out in Genova and Turin by Argan, Conte, Gonella, Picasso, Tomasini and myself. This research group has devoted its efforts particularly to two different trends of study.

1. The research on mixtures with hydrogen-rich components.
2. The research on mixtures with a high density and large atomic number components, for gas bubble chambers with a high stopping power and a high γ - conversion efficiency.

1. Mixtures with hydrogen rich components.

In order to set up gas bubble chambers of this kind, a systematic research was made on various mixtures of hydrocarbons; particularly on methane-propane, ethylene-propane and ethane-propane systems. Propane (Teb=42. 17°C; Tcrit=95.6°C; Pcrit=43kg/cm^2; density = 0.5 g/cm^3 at T=20°C) was found to be particularly advantageous, as a hydrogen rich liquid, because of some well known and remarkable physical characteristics; on the other hand, methane, ethylene and ethane gases are strongly soluble in propane and high concentrations may be obtained (especially with ethylene and ethane) at reasonably low equilibrium pressure (of the order of 24 ÷ 26 atmospheres).