rotated counter-clockwise, winding the softened glass in a spiral. After starting the spiral, the metal rod should rest on and be supported by the glass rod, and be about 3.2 to 6.4 mm. from the heated tip of the glass rod. By this process, the rod can be drawn to any desired diameter by varying the rate of turning. The space separating the turns is controlled by the angle at which the metal rod is held. With a little practice a uniform glass spiral can be wound having the size of No. 22 B. and S. wire, and about 10–12 turns per cm. This is easily removed from the rod when cool, and is broken up into single and double turns, which are sorted.

Fractionating columns packed with this material (usually 75% single, 25% double turns) have found a wide application in this Laboratory. This packing is far superior to the usual 5 × 5 mm. glass tubes. The flooding tendency is less (higher vapor velocity), enabling more rapid distillation, particularly under reduced pressures. The H. E. T. P. (height equivalent to a theoretical plate) of the new packing as determined by distilling a mixture of benzene and carbon tetrachloride[1] was 1.8 inches (4.57 cm.) in a total condensation, variable take-off column[2] with a packed section of 44 × 1.4 cm. and 2.0 inches (5.08 cm) in a similar column with 40 × 0.8 cm. packed section. The H. E. T. P. with 5 × 5 mm. glass tubes in a similar 40 × 1.4 cm. column was 4.0 inches (10.2 cm.). Thus by the use of the new packing the number of theoretical plates in a column can be more than doubled, while the distillation rate is also increased.

(1) Fenske, Quiggle and Tongberg, *Ind. Eng. Chem.*, **24**, 408 (1932).
(2) Whitmore and Lux, THIS JOURNAL, **54**, 3448 (1932).

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The Homogeneous Reaction between Hydrogen and Fluorine

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It has been reported by Moissan and Dewar[1] that immediate explosions are obtained when fluorine is brought into contact with liquid hydrogen. Since it seemed to us improbable that molecular hydrogen and molecular fluorine could react without considerable activation, we attempted to repeat this experiment. We were prevented from doing so by experimental mishaps; we did find, however, that there is no appreciable homogeneous reaction between the gases at room temperature.

Fluorine was obtained from a generator of the usual type and conducted through copper tubing to the center of a 3-liter flask. Hydrogen and nitrogen from tanks could also be admitted near the center; an exit tube also was provided. The ordinary procedure was to flush the flask out with nitrogen, and then to admit first one, then the other, of our reactant gases.

(1) H. Moissan and J. Dewar, *Compt. rend.*, **124**, 1202 (1894); **136**, 641, 785 (1903).

Under no circumstances did we observe a steady flame where the gases mingled. Sometimes we observed flashes from the copper tubing. In other experiments there would be no reaction for several minutes, and then a rather mild explosion, sufficient merely to blow the rubber stopper out of the bulb. In one experiment, in which we had admitted hydrogen first, a much larger quantity than usual of fluorine was added with no sign of reaction; we then waited for half an hour and finally decided to sweep the mixture out with nitrogen. A rapid flow of nitrogen was started, and immediately a very violent explosion occurred; the flask was pulverized, an enclosing towel cut into shreds and a wire-in-glass safety screen cracked in a dozen places. Presumably this explosion was initiated by sulfur, talc or other catalytic material from the rubber tubing of the nitrogen supply. In any case, there must have been for half an hour preceding the explosion, a mixture varying in composition from 100% hydrogen to 100% fluorine, without appreciable reaction occurring. The ionization from cosmic rays and local radioactivity may have started some chains. Unless branching occurred, very slight amounts of reaction would result. Since the atomic chains which we expect here cannot branch, we believe that the explosions observed are of the thermal type, occurring only when sufficient energy has been liberated in some small region. It is not impossible that explosions should be produced by the "bursts" of cosmic radiation that various observers have noted, but the normal ionization is certainly ineffective.

Our results are in agreement with the observations of Wartenberg and Taylor.[2] They agree also, as was previously suggested, with our theoretical expectations; the most exact formulation of these[3] predicts for

$$H_2 + F_2 = 2HF$$

an activation energy of over 50 kcal. Reaction by way of the atoms

$$F + H_2 = HF + H$$
$$H + F_2 = HF + F$$

should require little or no activation; the temperature coefficient of the thermal reaction occurring in this way should be due almost entirely to the temperature coefficient of the dissociation of fluorine; the over-all activation energy would be 30 to 40 kcal. Thus thermal reaction, by way of the atoms, should begin at 150–250°; it certainly cannot occur at liquid hydrogen temperature unless it is initiated by some very active catalyst, by discharge of static electricity, or other extraneous cause.

These experiments were made in 1930, at the University of California.

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(2) H. N. Wartenberg and J. Taylor, *Nachr. Ges. Wiss. Göttingen. Geschäft. Mitt. Math.-physik. Klasse*, **1**, 119 (1930).

(3) H. Eyring, THIS JOURNAL, **53**, 2537 (1931).