the infection throughout its prolonged illness, being in contact with *U3* on the thirty-second, *U4* on the forty-second, and *U5* on the forty-seventh day after generalization.

The character of the disease in rabbits *U5*, *U7* and *U8* was very much milder. The eyelids and face developed discrete swellings, but no general œdematous enlargement. The eyes did not close, nor did they discharge. The perineal region did not become greatly swollen. Three weeks after generalization all swelling had subsided, scars only marking the sites of the larger tumours. The animals never lost condition, and remained fit enough to fight their cage-mates.

Rabbit *U3* was outstanding in the mildness of its infection; in fact, myxomatosis could scarcely have been diagnosed from the clinical symptoms. Generalization was marked by a very slight inflammation of the eyelids, anus and preputium. Later, the only indication of lesions, which had produced no palpable swellings, were ruffled fur around the base of the ears and on the front of the face. When the animal was sacrificed eight days after generalization, the only signs of infection were numerous small lesions on the skin of the body, a very slight asymmetrical swelling of the genital organs, and some small tumours on the upper eyelids, the top of the nose, and at the bases of the ears.

The case-histories of the animals used in this study indicate that a modified strain of lowered virulence has appeared in the field. The possibility of all the experimental rabbits possessing an enhanced genetic resistance seems too remote for serious consideration: they were obtained from different parts of the Territory and, moreover, Prof. Fenner[4] reports that the Uriarra strain of the virus is producing an atypical disease in laboratory rabbits, which, of course, come from a population without a previous history of contact with the infection.

Two variants of the myxomatosis virus of greatly reduced virulence have appeared in the laboratory, Hurst's[5] neuromyxoma and Berry's[6] strain 80*A*. This is the first recorded recovery from an epizootic in a wild rabbit population of a strain of the virus modified to a degree comparable with these two laboratory variants. I have also indications, based on the observation of naturally infected rabbits, of the occurrence of atypical mild infections in two other localities within the Australian Capital Territory; and Fenner[7] now has evidence that somewhat attenuated strains may have appeared in the field in other parts of Australia. [May 4.

(*Note added in proof. July* 21.) Since the above report was written, the passaging, by contact infection, of the Uriarra 'strain' of the myxoma virus has been continued. Five more rabbits have made complete recoveries, while one animal (which proved to be heavily infected with coccidia) has succumbed. However, virus recovered from mild cases, and inoculated into test animals for various purposes, has failed to produce the non-lethal disease characteristic of the contact-infection series. Thus the overwhelming majority of the animals infected by mosquitoes that had fed on a rabbit inoculated with material from rabbit No. *U3* have died, though these fatal infections have been rather atypical[8].

It is not easy to see how the mere difference in the mechanism of infection (that is, by contact—whatever this may involve—and by intradermal inoculation or mosquito bite) could provide a satisfactory explanation of these contrasting results. It has been suggested[9] that the Uriarra 'strain' is a mixture of strains including a variant of low virulence, the complex character of which has somehow been maintained through the series of contact infections. Information on the behaviour of infections by more than one strain of the myxoma virus appears to be limited to the results of some experiments by Dr. L. B. Bull[10], who used Martin's strain *B* and Hurst's neuromyxoma. The disease produced was mild, although only fully virulent virus was recovered from the animals that had been simultaneously infected by both strains.

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EXPLOSIONS IN MIXTURES OF HYDROGEN, CHLORINE AND NITROGEN TRICHLORIDE

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IT is well known that nitrogen trichloride will inhibit the photochemical reaction between hydrogen and chlorine when the total pressure of the reactants is about atmospheric. We have recently shown, on the other hand, that at low pressures traces of nitrogen trichloride cause an explosive combination of the hydrogen and chlorine in the dark after an induction period. These low-pressure, low-temperature explosions have been examined by making up mixtures of nitrogen trichloride, chlorine and hydrogen, and of nitrogen trichloride, chlorine and nitrogen for comparison, at high pressures, and then admitting a selected pressure of the chosen mixture to an evacuated reaction vessel. This vessel was cylindrical, of internal diameter 30 mm., and was held in a thermostat and shielded from light. Explosions of mixtures of hydrogen, chlorine and nitrogen trichloride were accompanied by a bright flash and were audible; when nitrogen replaced the hydrogen, the explosion was extremely faint, but a sharp kick was registered on the Bourdon gauge and was attributed to the explosive decomposition[2] of the nitrogen trichloride. Whenever slow decomposition of the nitrogen trichloride occurred, it was followed by the accompanying pressure change due to the overall reaction: $2NCl_3 \rightarrow N_2 + 3Cl_2$. After a reaction in mixtures of hydrogen, chlorine and nitrogen trichloride, the gases were withdrawn through spirals surrounded with liquid nitrogen, so that the amount of hydrogen chloride formed could be estimated.

The nitrogen trichloride was prepared by running excess of chlorine into a mixture of ammonia and hydrogen or nitrogen. The addition of the hydrogen or nitrogen keeps the pressure above the upper limit

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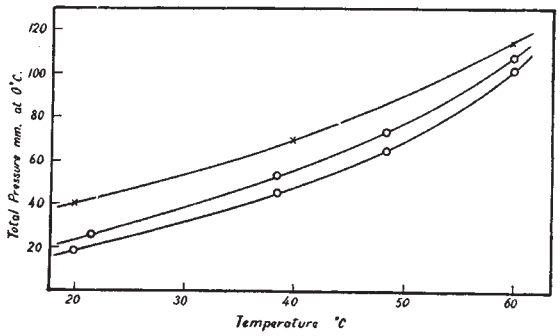

Fig. 1. Variation of the upper limit of ignition with temperature. Bottom curve for equimolar nitrogen and chlorine, middle curve for equimolar hydrogen and chlorine, each with about 1 per cent nitrogen trichloride; the top curve gives Apin's values for nitrogen trichloride alone

for explosion at room temperature (see Fig. 1), so preventing the ignitions sometimes observed[1] when chlorine is run into ammonia alone. Very little of the hydrogen used as a diluent was converted to hydrogen chloride; this result would be expected from the molecular mechanism usually postulated for the reaction: $4NH_3 + 3Cl_2 \rightarrow NCl_3 + 3NH_4Cl$.

The principal results observed were as follows:

(1) Explosions occur in both the hydrogen, chlorine, nitrogen trichloride system and the nitrogen, chlorine, nitrogen trichloride system below a reproducible pressure (the upper limit). Experiments were not made to investigate any possible lower limit.

(2) The upper limit appears to be independent of the proportion of nitrogen trichloride in the mixtures, once this is above 0·1 per cent, up to the highest proportion used (2·0 per cent).

(3) The upper limit varies with temperature as shown in Fig. 1, where the curves for hydrogen plus chlorine and for nitrogen plus chlorine in the presence of 1 per cent of nitrogen trichloride are compared with the curve for nitrogen trichloride alone as determined by Apin[2].

(4) Below the upper limit, the hydrogen and chlorine in mixtures of hydrogen, chlorine and nitrogen trichloride are converted completely to hydrogen chloride; immediately above, the proportion converted falls abruptly to zero. In nitrogen, chlorine, nitrogen trichloride mixtures, the nitrogen trichloride decomposes explosively and completely at pressures below the upper limit.

(5) For both mixtures the rate of decomposition of the nitrogen trichloride at pressures just above

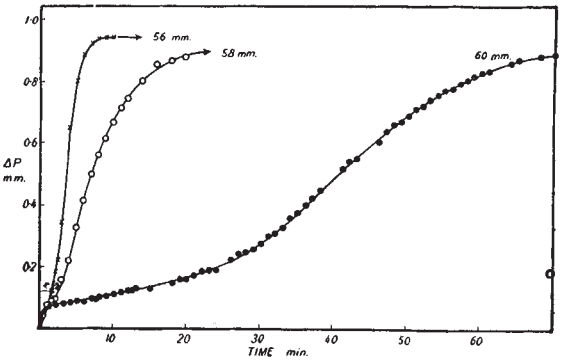

Fig. 2. Increase of pressure due to the slow decomposition at 38·4° C. of nitrogen trichloride in the presence of equimolar mixtures of hydrogen and chlorine at pressures (shown in mm. at 0° C.) just above the upper limit (55 mm.)

the upper limit follows an *S*-shaped curve; as the total pressure increases, the maximum rate falls off very rapidly and the time elapsing before the maximum rate is reached increases greatly. Typical results are shown in Fig. 2.

(6) There is an induction period before all explosions which presumably corresponds to the time taken by the decomposition of the nitrogen trichloride to reach its maximum rate. The induction period increases rapidly but smoothly as the pressure increases through the upper limit.

(7) Traces of nitrosyl chloride eliminate the explosions in hydrogen, chlorine, nitrogen trichloride and in nitrogen, chlorine, nitrogen trichloride mixtures. This is probably due to rapid reactions such as:

$$NOCl + Cl \rightarrow NO + Cl_2,$$

which remove the chain centres responsible for the explosive decomposition of the nitrogen trichloride.

(8) A few runs with methane in place of hydrogen showed that it was chlorinated rapidly below an upper pressure limit; there was no visible ignition, but there was a very strong kick on the Bourdon gauge.

The parallel behaviour of the systems hydrogen, chlorine, nitrogen trichloride and nitrogen, chlorine, nitrogen trichloride suggests that the explosive combination of the hydrogen and chlorine is triggered by centres provided by the thermal decomposition of the nitrogen trichloride. In order to account for the upper limits observed in these experiments and by Apin, the thermal decomposition must be assumed to proceed by a branched-chain mechanism. Norrish and Griffiths[1] suggested that the chlorine-photosensitized decomposition involved the propagating steps:

$$Cl + NCl_3 \xrightarrow{k_2} NCl_2 + Cl_2$$

and

$$NCl_2 + NCl_3 \xrightarrow{k_3} N_2 + 2Cl_2 + Cl,$$

and the terminating step

$$Cl + NCl_3 + M \xrightarrow{k_T} NCl_4 + M.$$

In the thermal decomposition, the chain-initiating step is probably:

$$NCl_3 \xrightarrow{k_1} NCl_2 + Cl.$$

This is followed by the two propagating steps, the the second of which is highly exothermic and might occasionally take the course

$$NCl_2 + NCl_3 \xrightarrow{k_B} N_2 + Cl_2 + 3Cl$$

and so give positive branching. The competition between reactions k_B and k_T leads to an upper pressure limit P_U given by:

$$P_U (k_T' f' + k_T'' f'' + \ldots.) = k_B \frac{k_2}{k_3},$$

where f', f'', etc., are the mole fractions of the gases in the mixtures and k_T', k_T'', etc., the corresponding velocity constants for the chain-terminating steps. The upper limit is thus independent of nitrogen trichloride, as observed experimentally, but varies with the composition of the mixture.

I am grateful to Prof. R. G. W. Norrish and to Prof. F. S. Dainton for many stimulating discussions about this work. [Feb. 27.

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