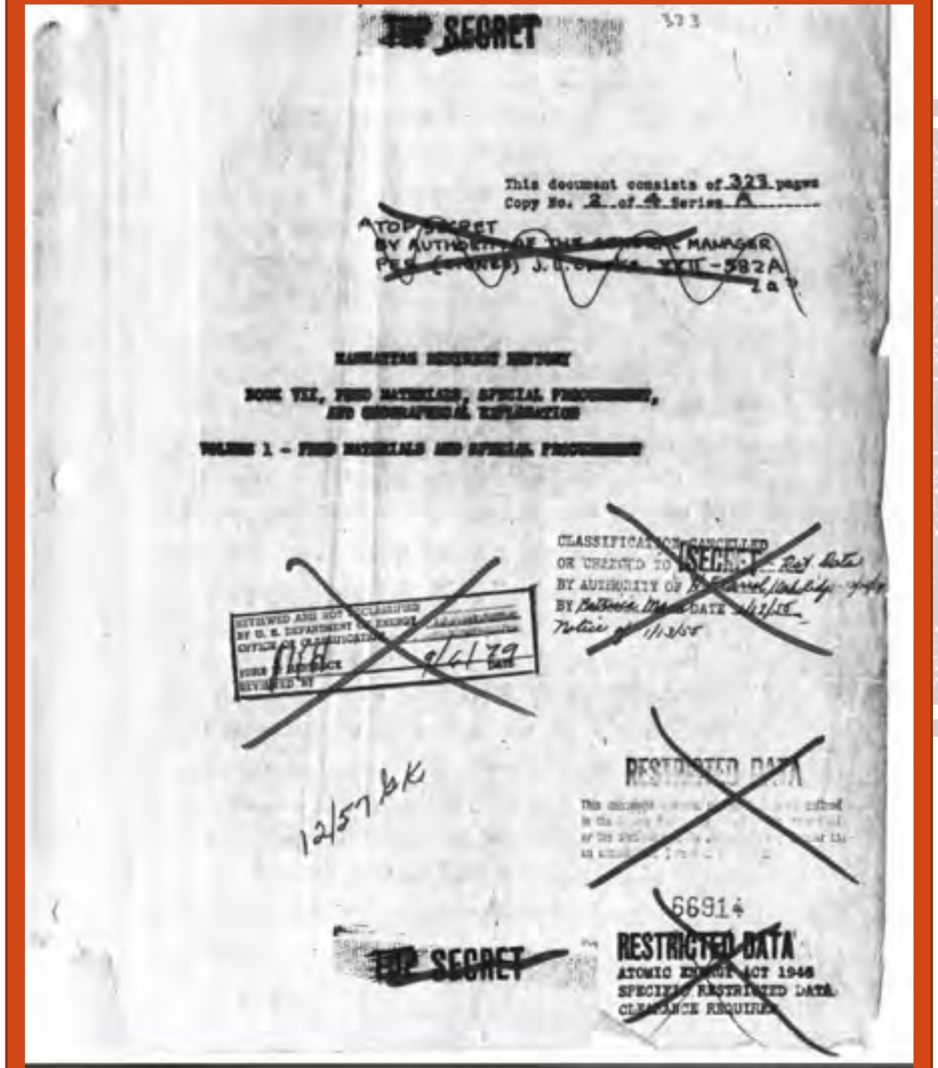
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THE PROVING GROUNDS

Fluorocarbons & The Bomb

Rebecca Altman, PhD

MID-OHIO VALLEY

(2007)

Source: Greenpeace-UK 2005

Source: M. Costantini (San Francisco Chronicle) 2000

PERFLUOROOCTANOIC ACID

POLYCHLORINATED BIPHENYLS

POLYBROMINATED BIPHENYLS & DIPHENYL ETHERS

THE SIMONS PROCESS (ECF)

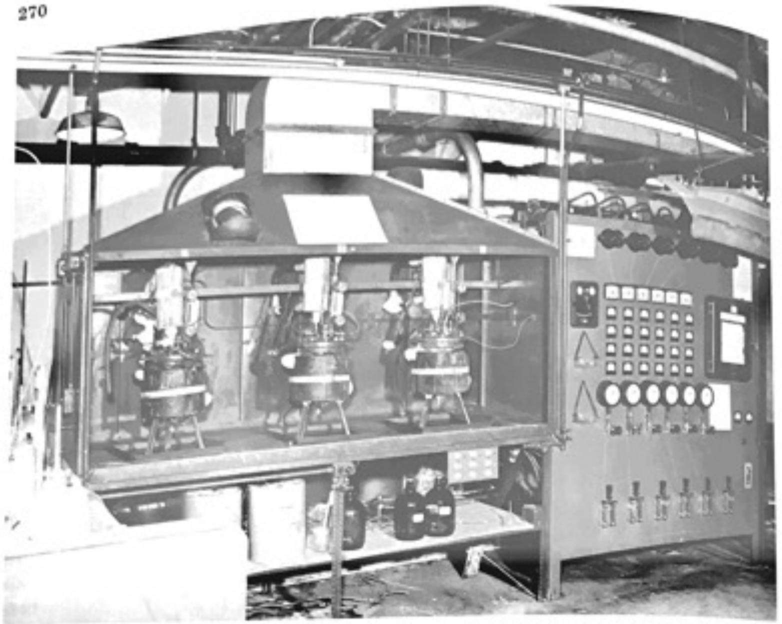
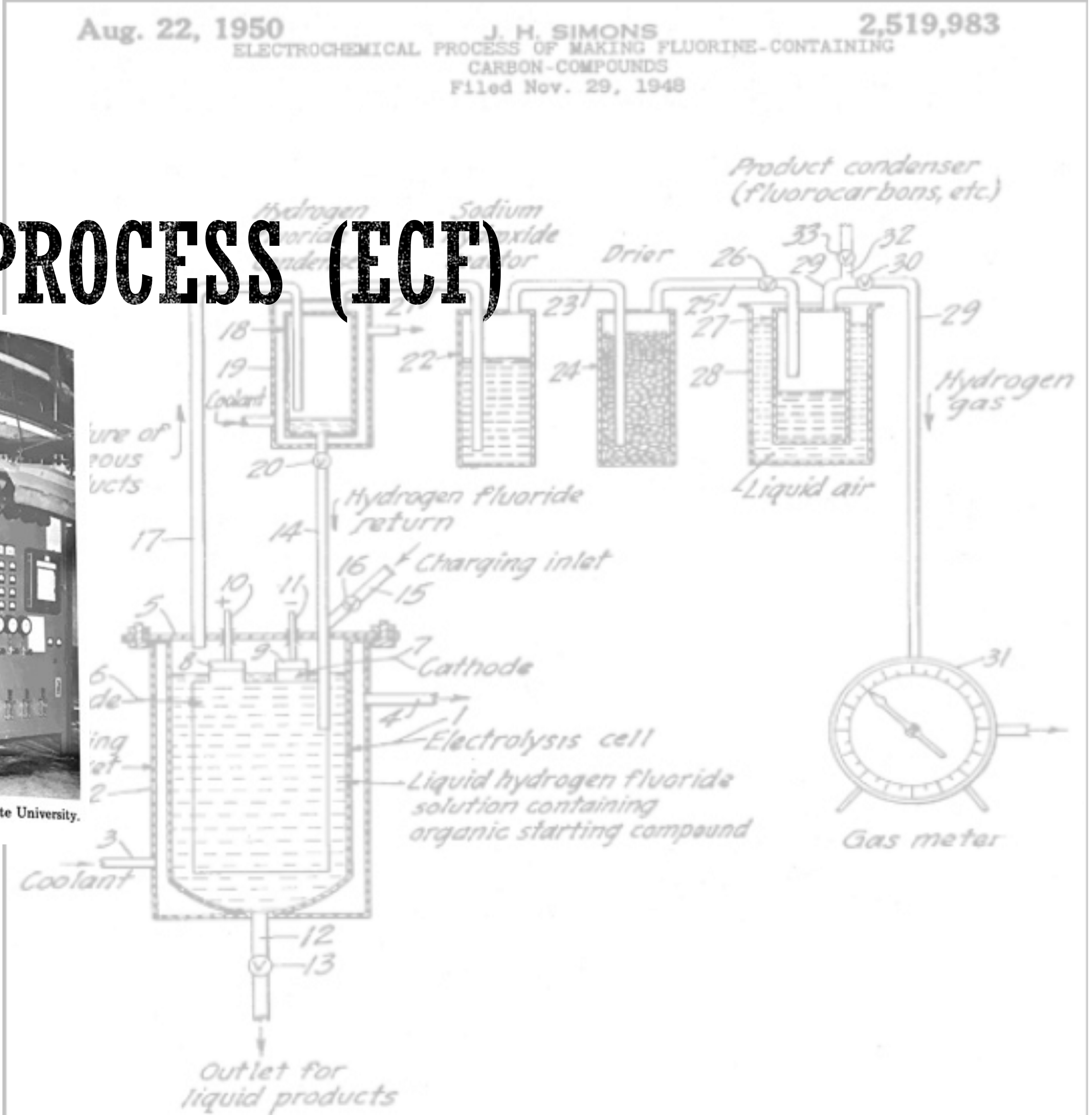
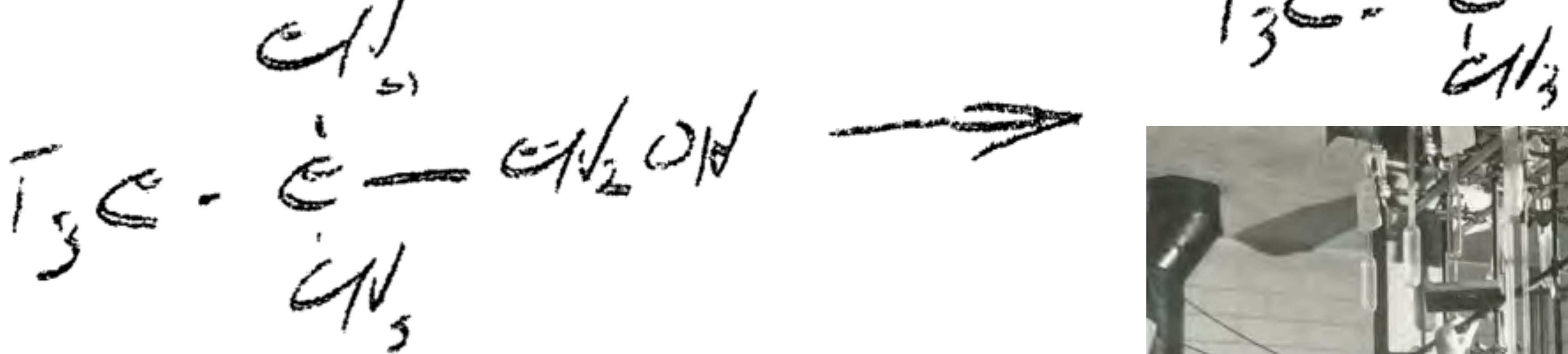


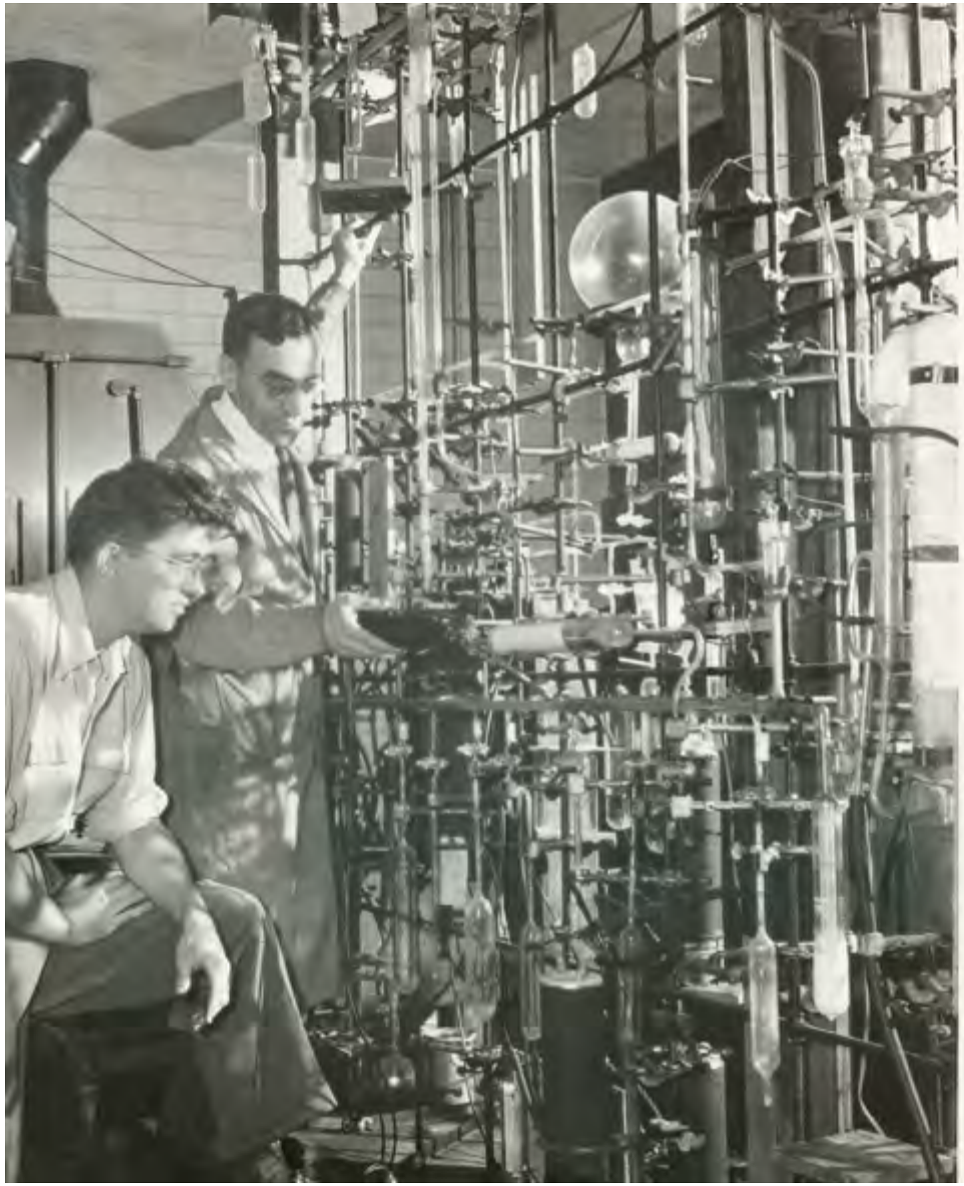
Fig. 11.3. Simons' ECF cells in the Fluorine Laboratories at Pennsylvania State University.





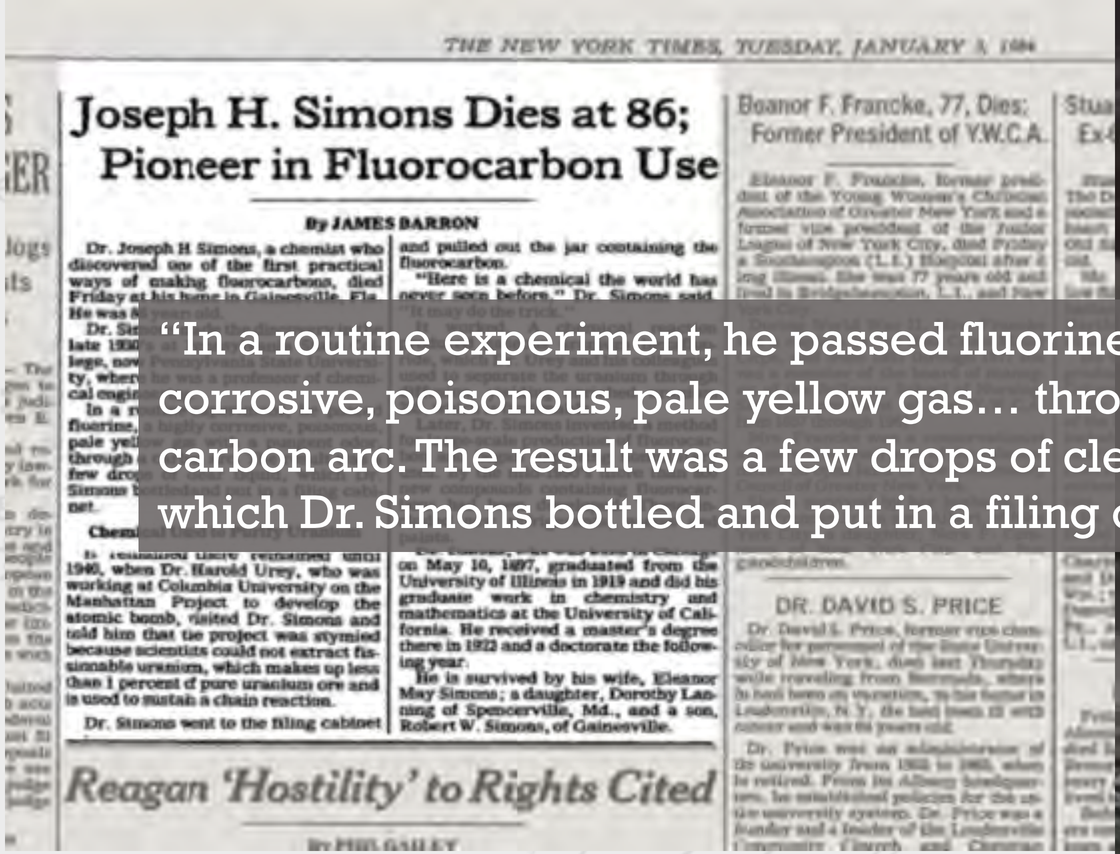
JOSEPH H. SIMONS

Penn State College



Images: PSU Archives

"JOE'S STUFF"



THE NEW YORK TIMES, TUESDAY, JANUARY 3, 1984

Joseph H. Simons Dies at 86; Pioneer in Fluorocarbon Use

By JAMES BARRON

Dr. Joseph H Simons, a chemist who discovered one of the first practical ways of making fluorocarbons, died Friday at his home in Gainesville, Fla. He was 86 years old.

...

It remained there until 1940, when Dr. Harold Urey, who was working at Columbia University on the Manhattan Project to develop the atomic bomb, visited Dr. Simons and told him that the project was stymied because scientists could not extract fissionable uranium, which makes up less than 1 percent of pure uranium ore and is used to sustain a chain reaction.

Dr. Simons went to the filing cabinet and pulled out the jar containing the fluorocarbon.

"Here is a chemical the world has never seen before," Dr. Simons said.

...

on May 10, 1897, graduated from the University of Illinois in 1919 and did his graduate work in chemistry and mathematics at the University of California. He received a master's degree there in 1922 and a doctorate the following year.

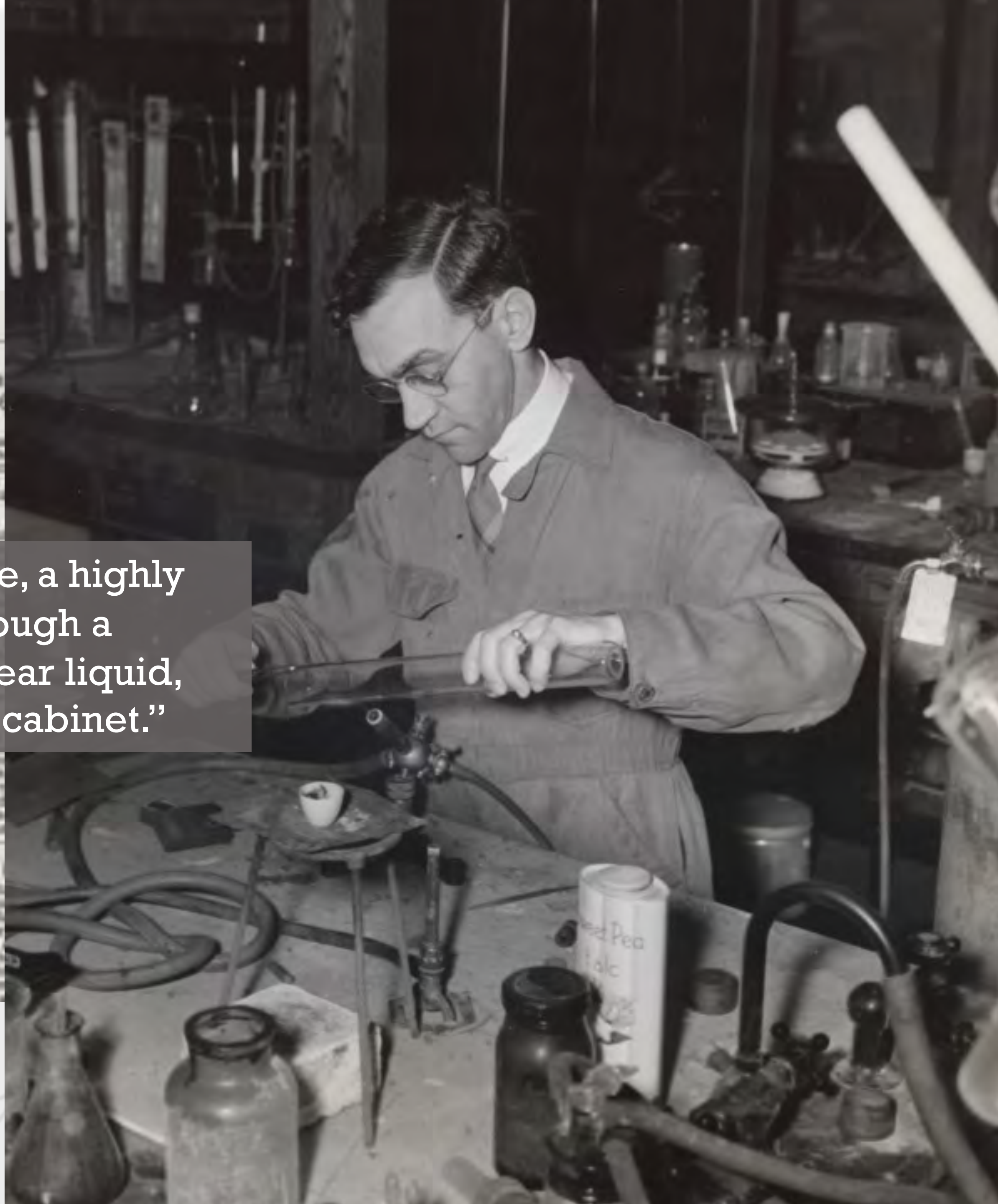
He is survived by his wife, Eleanor May Simons; a daughter, Dorothy Lanning of Spencerville, Md., and a son, Robert W. Simons, of Gainesville.

Eleanor F. Francke, 77, Dies; Former President of Y.W.C.A.

DR. DAVID S. PRICE

Reagan 'Hostility' to Rights Cited

"In a routine experiment, he passed fluorine, a highly corrosive, poisonous, pale yellow gas… through a carbon arc. The result was a few drops of clear liquid, which Dr. Simons bottled and put in a filing cabinet."



1939

The New York Times.

EXTRA

GERMAN ARMY ATTACKS POLAND; CITIES BOMBED, PORT BLOCKADED; DANZIG IS ACCEPTED INTO REICH

Hitler Tells the Reichstag 'Bomb Will Be Met by Bomb'

It now appears that Professor Chichibabin did not as a matter of fact report the diazotate reaction as a method for the preparation of alpha-phenoxypyridine, its isolation being merely incidental in the reaction which he was investigating. Unfortunately, we had only abstracts of the Russian article at our disposal.

The designation of 2-phenoxypyridine as the only alpha-substituted pyridine reported in the literature (page 297) is a very patent error, since a large number of alpha-substituted pyridines have been known for many years and the writer had dealt with derivatives of such compounds in two earlier publications, as well as in the paper under discussion. (Note reference to Grave's article page 298.) On examination it was found that this error was due to the accidental omission of *aryloxy-* after *alpha-* in the term "alpha-substituted pyridine," in the final typing of the manuscript.

NEW YORK UNIVERSITY R. R. RENSHAW
NEW YORK CITY

RECEIVED MARCH 31, 1937

FLUOROCARBONS

Sir:

From a reaction mixture of carbon and fluorine the following fluorocarbons have been isolated and identified by their molecular weights: profluorane, C_3F_8; bufluorane, C_4F_{10}; pentfluorane, C_5F_{12}; and hexfluorane, C_6F_{14}. The well-known compounds methfluorane, CF_4, and ethfluorane, C_2F_6, were also formed in the reaction. The separation was made by distillation and the molecular weights were determined with an all-glass density balance. Seven to fi... pound was obtained. ... points have been dete... are: profluorane f. ... bufluorane f. p. −84.5° ... f. p. −10°, b. p. +30°; and hexfluorane f. p. −4°, b. p. +60°.

The distillation was performed in a low temperature column packed with glass helices. It was carried out at 200 mm. and the temperature remained constant within 1° during the collection of each fraction. The molecular weights as obtained from the density balance and determined at short intervals during the distillation remained constant so long as the temperature remained constant. Each fraction was redistilled and the same molecular weights obtained: C_3F_8 184, 188; C_4F_{10} 234, 238; C_5F_{12} 277, 288; and C_6F_{14} 328, 338. The precision of the density balance decreased as the molecular weight increased, and the increased adsorption of the higher boiling substances resulted in low values. The balance was calibrated with oxygen and carbon dioxide and was checked with CF_4 and C_2F_6, which gave the theoretical values of 88 and 138 ...

... (1935)] and investigated by Aten and Urey [*Phys. Rev.*, **50,** 575 (1936)] and using the apparatus devised by Huffman and Urey [*Ind. Eng. Chem.*, **29,** 531 (1937)] we have attempted to concentrate the ...

... pressure, liberating the ammonia from the salt in solution at the bottom by the addition of sodium hydroxide and stripping the ammonia from the solution by a packed stripping column. This ammonia was fed back to the bottom of the column and escaped from the top. As the result of a thirteen-day run of this kind we have produced nitrogen containing 2.54% of N^{15}, a $6^1/_4$ fold increase in concentration.

The transport of heavy ammonia is equal to the total flow multiplied by the difference in concentration of heavy ammonia in the solution and gas

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, THE PENNSYLVANIA STATE COLLEGE]

Fluorocarbons. The Reaction of Fluorine with Carbon

BY J. H. SIMONS AND L. P. BLOCK[1]

Carbon tetrafluoride has been obtained from the reaction of fluorine with carbon.[2] Ruff and Keim isolated hexafluoroethane from the reaction products and obtained small amounts of higher boiling material, which they assumed to be mixtures of higher molecular weight fluorocarbons, but in insufficient quantity to separate and isolate the compounds. Several difficulties are encountered in the study of this reaction. Frequent and sometimes violent explosions occur; and as the higher molecular weight compounds are produced in relatively small quantities, large amounts of reaction products are necessary in order to ...

(1) The authors gratefully acknowledge a grant from the American ...

J of American Chem Society 1939

J of American Chem Society 1937

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work ... municated to me in m... ium may be turned ... mediate future. ... to call for wat... of the Admini... to your att...

In ... through ... Ameri... in ... it ...

-2-

The United States has only very poor ores of uranium in mode... quantities. There is some good ore in Canada and the former Czechosl... while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an inofficial capacity. His task might comprise the following:

a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

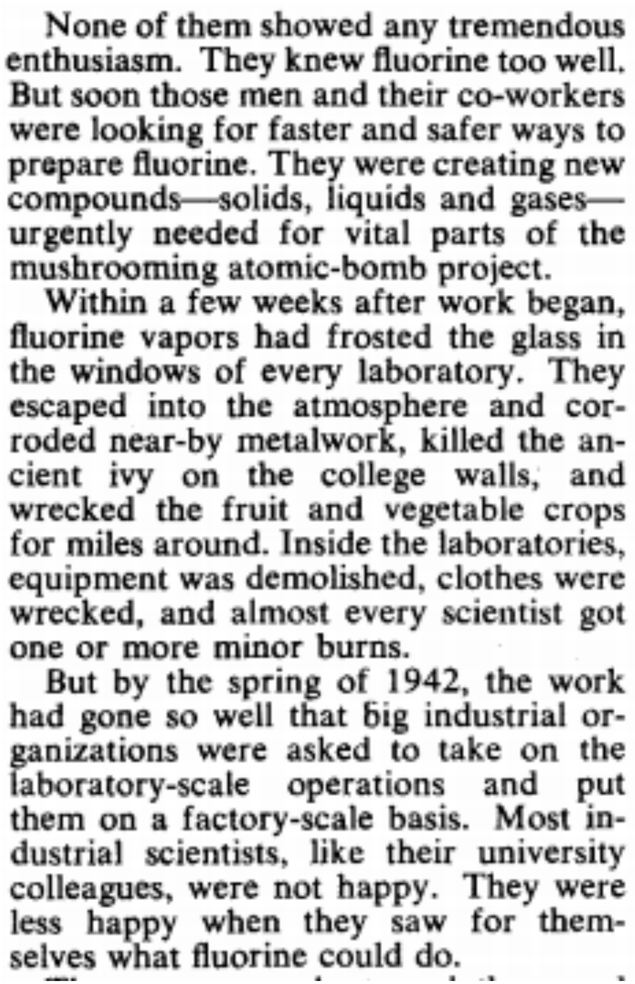
b) to speed up the experimental work, which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weiz..., is attached to the Kaiser-Wilhelm-Institut in Berlin where ... American work on uranium is now being repeated.

Yours very truly,
A. Einstein
(Albert Einstein)

264a02

1941 1942 1943 1944



None of them showed any tremendous enthusiasm. They knew fluorine too well. But soon those men and their co-workers were looking for faster and safer ways to prepare fluorine. They were creating new compounds—solids, liquids and gases—urgently needed for vital parts of the mushrooming atomic-bomb project.

Within a few weeks after work began, fluorine vapors had frosted the glass in the windows of every laboratory. They escaped into the atmosphere and corroded near-by metalwork, killed the ancient ivy on the college walls, and wrecked the fruit and vegetable crops for miles around. Inside the laboratories, equipment was demolished, clothes were wrecked, and almost every scientist got one or more minor burns.

But by the spring of 1942, the work had gone so well that big industrial organizations were asked to take on the laboratory-scale operations and put them on a factory-scale basis. Most industrial scientists, like their university colleagues, were not happy. They were less happy when they saw for themselves what fluorine could do.

Silverman 1949)

MANHATTAN DISTRICT

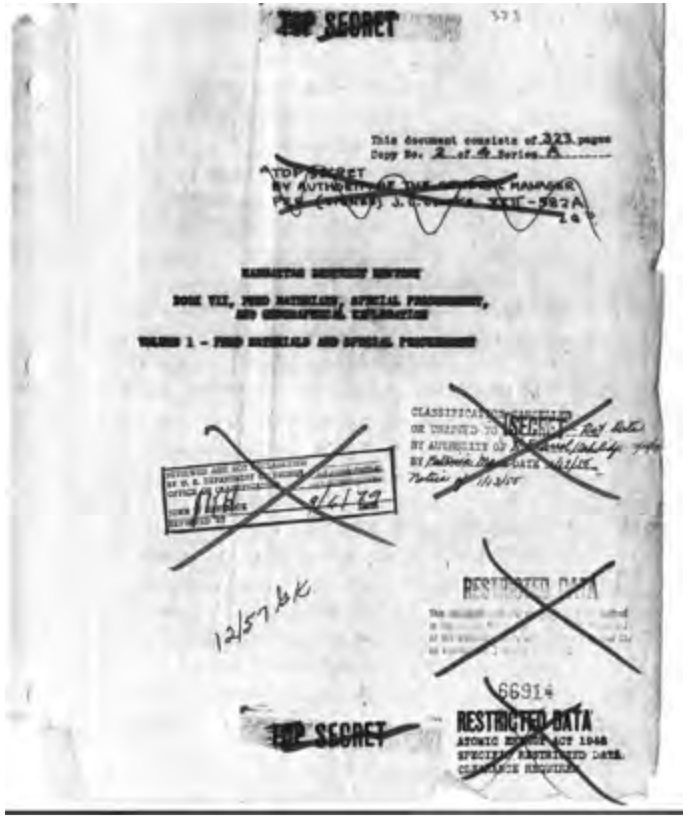
Mid-1941: feasibility tests & “exploration”

Early 1942: “serious, coordinated lab effort”

Late 1942: engineering, scale-to-factory

1943 Construction at Oak Ridge begins

FLUOROCARBONS AT OAK RIDGE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C-216	-	Fluorine
C-2144	-	Fluorinated lube oil
C-2144S	-	Chlorofluorolube oil (from terphenyls)
C-714	-	Mixture of tetradecafluoromethylcyclohexane and tetradecafluoroethylcyclopentane
C-715CL	-	Chloro-pentadecafluoro-heptane
C-716	-	n-perfluoroheptane
C-816	-	Perfluorodimethylcyclohexane
C-816CL	-	Monochloro-pentadeca dimethylcyclohexane
FL	-	Fluorolube
FLS	-	Fluorinated lubricant solvent or fluorinated kerosene
Freon 113	-	Trichloro-trifluoro-ethane
HF	-	Hydrofluoric acid
MFL	-	Polymerized and further fluorinated trifluorochloro-ethylene (liquid)
MFI	-	Polymerized and further fluorinated trifluorochloro-ethylene (grease)
OG	-	Fluorine
P-45	-	Hexafluoroxylene
P-45CL	-	Monochlor P-45
$P-45CL_2$	-	Dichlor P-45
P-539	-	Trifluorochloroethylene

~~SECRET~~

[redacted]

OAK RIDGE (GASEOUS DIFFUSION)

Energy.gov

PTFE (THEN POLY-F1114)...


April 1938

Image: Hagley Museum & Library

Plunket

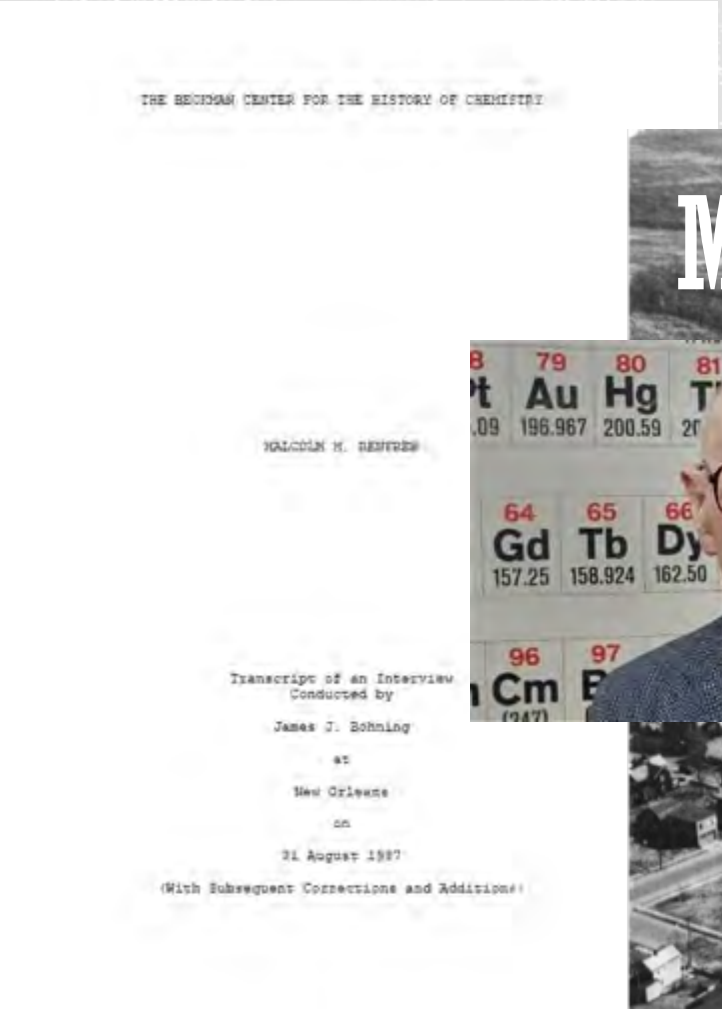
(Spring 1938)

ARLINGTON WORKS (KEARNY, NJ)

Built to make celluloid plastics – bought by DuPont after WWI

The Birthplace of industrial Teflon

MALCOLM RENFREW



THE BECKMAN CENTER FOR THE HISTORY OF CHEMISTRY

MALCOLM M. RENFREW

Transcript of an Interview
Conducted by

James J. Bohning

at

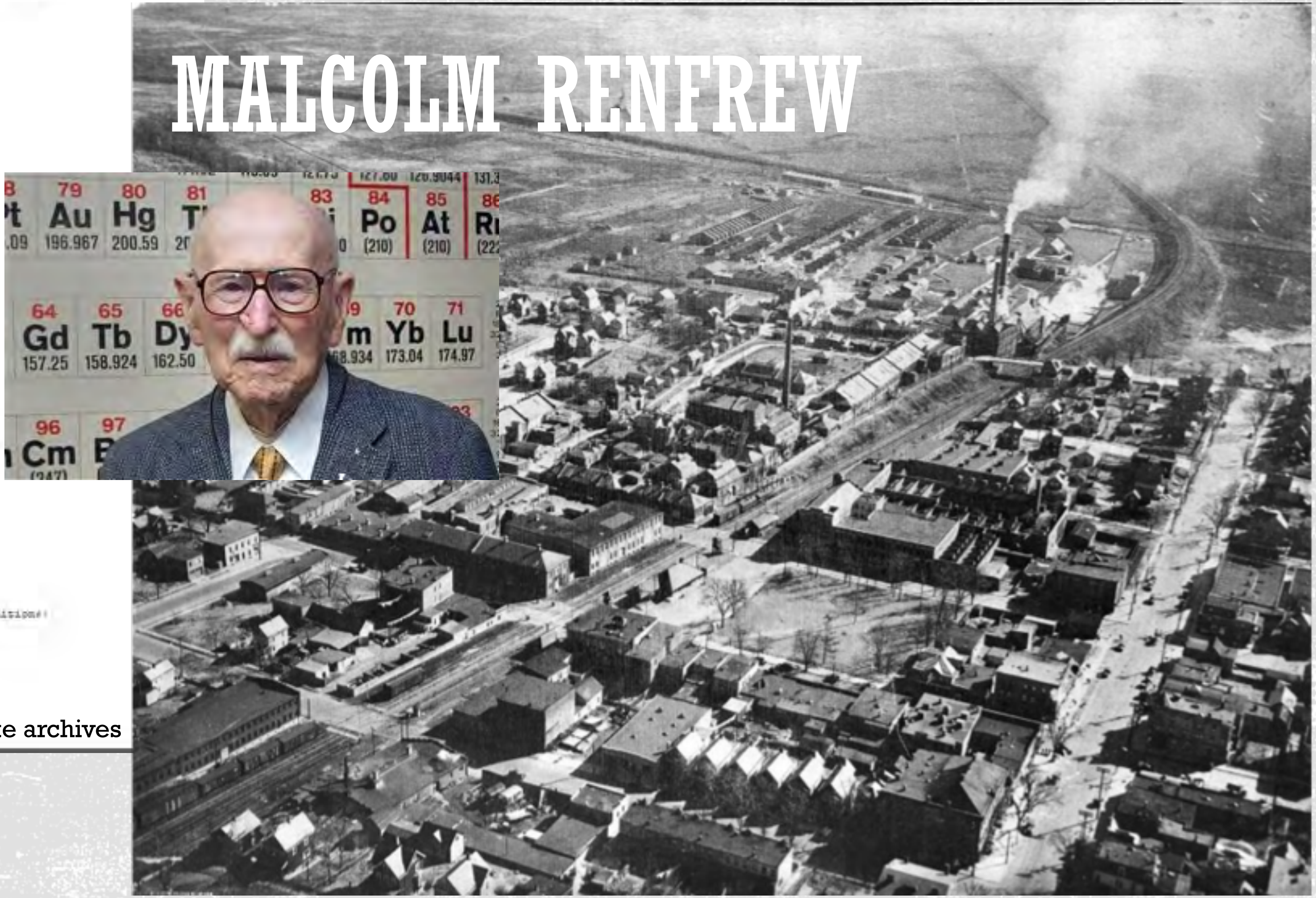
New Orleans

on

31 August 1987

(With Subsequent Corrections and Additions)

Via the Science History Institute archives

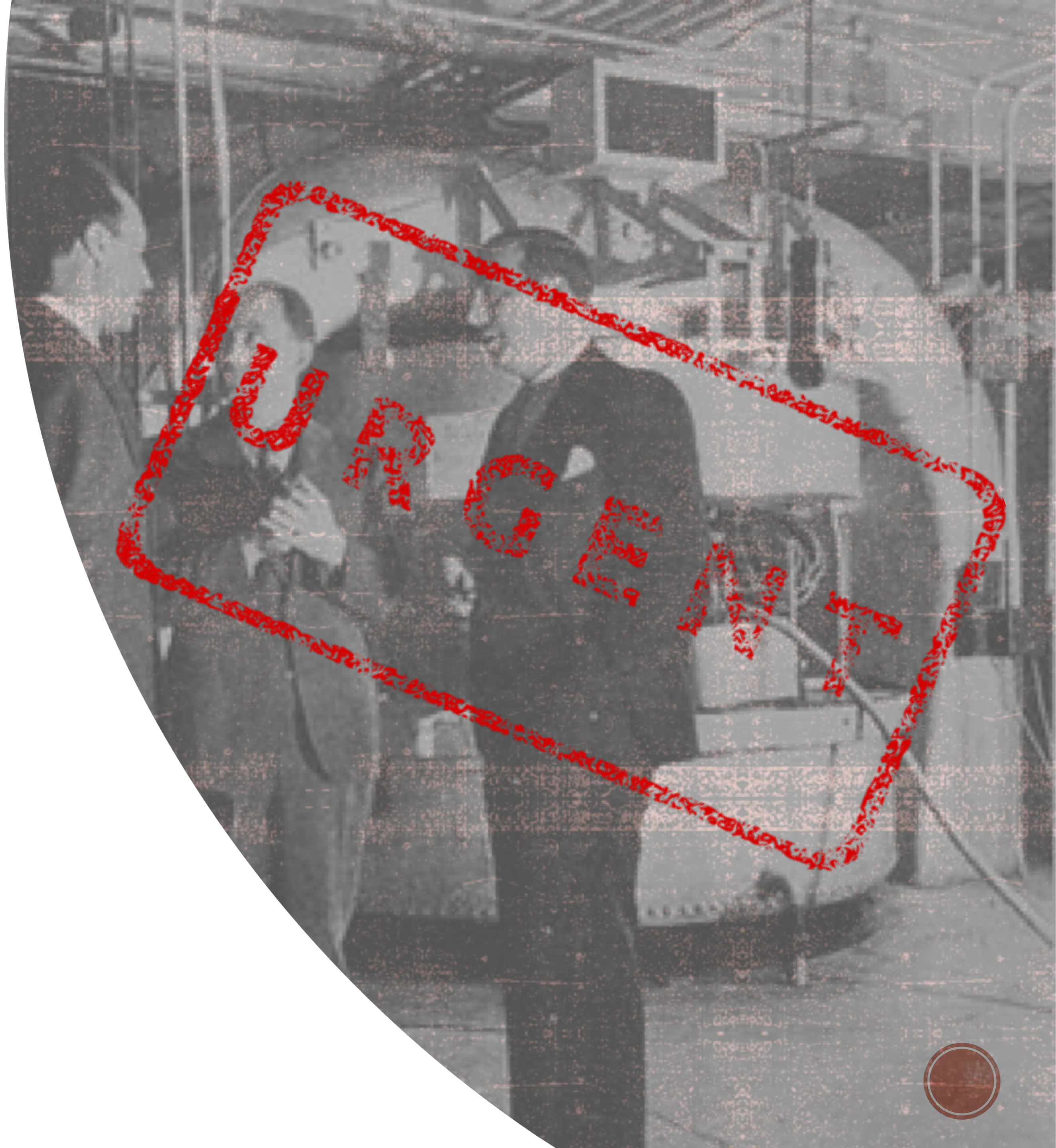


DUNNING CALLS RENFREW TO COLUMBIA

"There was soon going to be urgent demands for what we then called poly-F1114. He had a schedule for us to meet: we were to have 1 week to complete our development work on the polymerization process; we would have 2 weeks for the design of the plant; we would have 1 week for plant construction, and then we were supposed to be producing polytetrafluoroethylene at the rate (I think) of a million pounds a month! Now, it may have been a million pounds a year, but I think it was a million pounds a month! We never made that schedule."

Malcolm Renfrew

via Science History Institute oral history archives

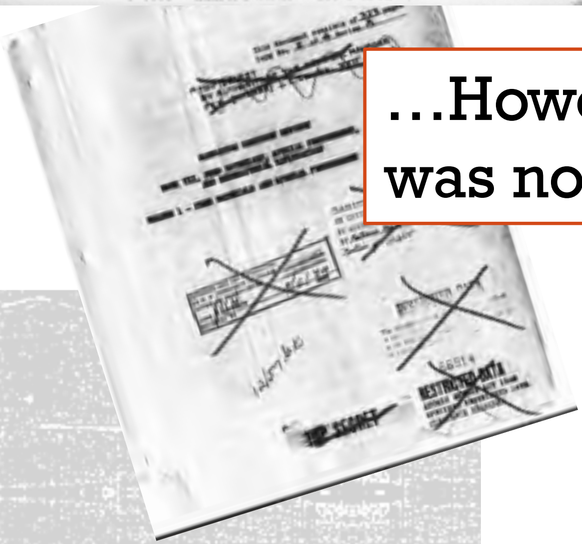


"… the pilot plant stage is where processes are apt to run into accidents. Even at best, the hazards are there because you're doing new things with scaled-up quantities. And so we had our troubles."

Malcolm Renfrew
Via Science History Institute

tracks

according to interview with Mildred Hayner, employee during WWII, approx. location 1944 explosion



n the years immediately before the war by polymeriza-
tetrafluorethylene, which was derived from a Freon.
his was particularly a du Pont product, arrangements
de to meet requirements by purchase of the material
Pont.
eliminary requirements indicated that very large
would be necessary and it was intended that a plant
built by the Government in which du Pont could
produce the required amounts. However, further research

…However, further research indicated that this material was not as satisfactory as originally expected…

be very much smaller. All material was subsequently obtained on normal purchase orders. Also arrangements were made with du Pont to provide for the priority of the Manhattan District orders and for suitable security arrangements with respect to the use of this material by the District.

HIROSHIMA

August 1945

NAGASAKI

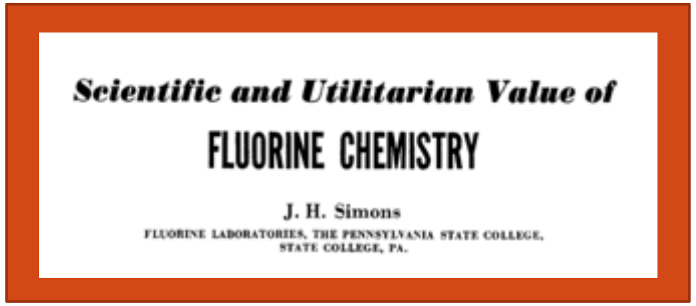
August 1945

Library of Congress

SECRECY ORDERS LIFTED

PATENTS & PUBLICATIONS RELEASED

"… the breathtaking pace at which they were brought about…" (March 1947)

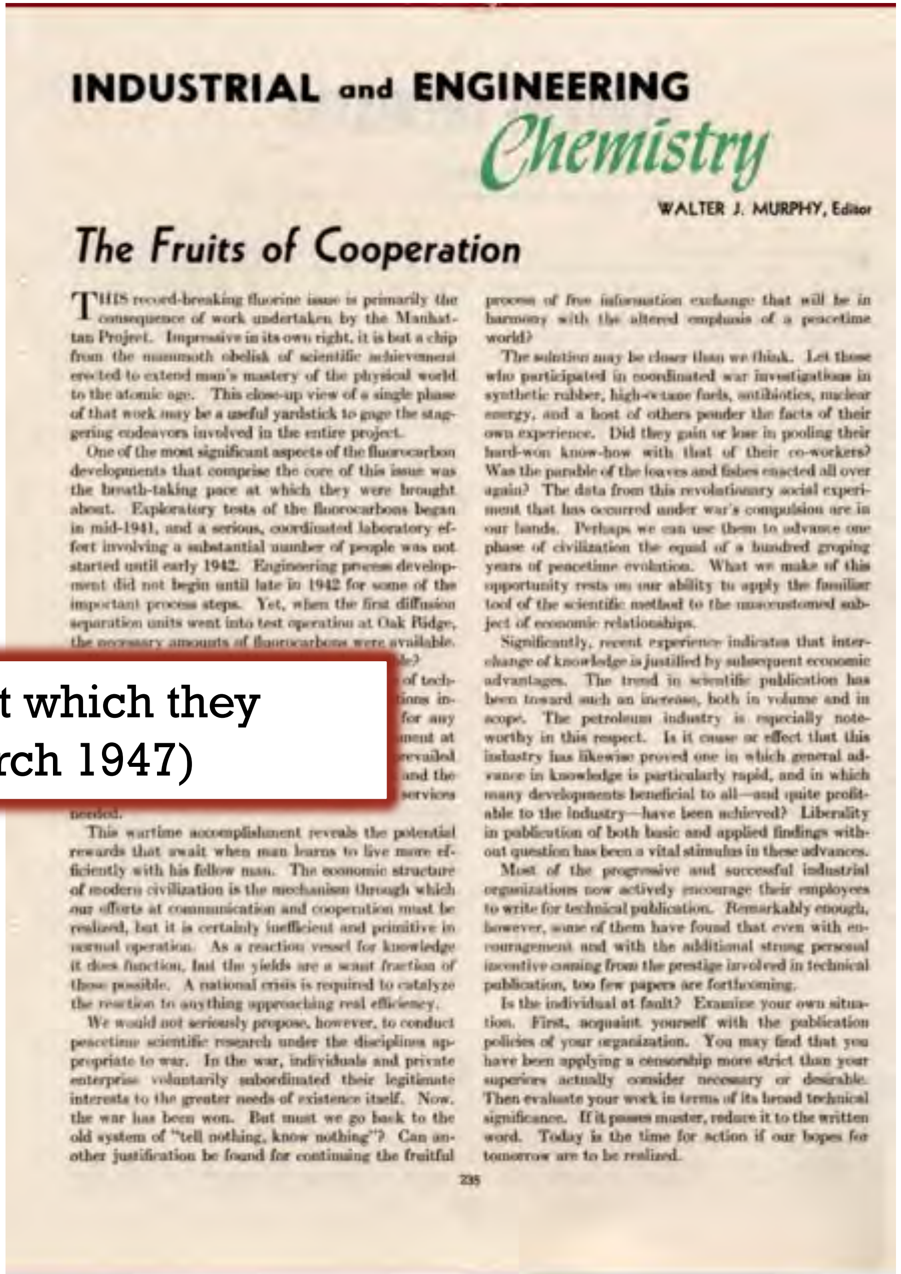


Scientific and Utilitarian Value of

FLUORINE CHEMISTRY

J. H. Simons

FLUORINE LABORATORIES, THE PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PA.



INDUSTRIAL and ENGINEERING *Chemistry*

WALTER J. MURPHY, Editor

The Fruits of Cooperation

THIS record-breaking fluorine issue is primarily the consequence of work undertaken by the Manhattan Project. Impressive in its own right, it is but a chip from the mammoth obelisk of scientific achievement erected to extend man's mastery of the physical world to the atomic age. This close-up view of a single phase of that work may be a useful yardstick to gage the staggering endeavors involved in the entire project.

One of the most significant aspects of the fluorocarbon developments that comprise the core of this issue was the breath-taking pace at which they were brought about. Exploratory tests of the fluorocarbons began in mid-1941, and a serious, coordinated laboratory effort involving a substantial number of people was not started until early 1942. Engineering process development did not begin until late in 1942 for some of the important process steps. Yet, when the first diffusion separation units went into test operation at Oak Ridge, the necessary amounts of fluorocarbons were available.

… needed.

This wartime accomplishment reveals the potential rewards that await when man learns to live more efficiently with his fellow man. The economic structure of modern civilization is the mechanism through which our efforts at communication and cooperation must be realized, but it is certainly inefficient and primitive in normal operation. As a reaction vessel for knowledge it does function, but the yields are a scant fraction of those possible. A national crisis is required to catalyze the reaction to anything approaching real efficiency.

We would not seriously propose, however, to conduct peacetime scientific research under the disciplines appropriate to war. In the war, individuals and private enterprise voluntarily subordinated their legitimate interests to the greater needs of existence itself. Now, the war has been won. But must we go back to the old system of "tell nothing, know nothing"? Can another justification be found for continuing the fruitful process of free information exchange that will be in harmony with the altered emphasis of a peacetime world?

The solution may be closer than we think. Let those who participated in coordinated war investigations in synthetic rubber, high-octane fuels, antibiotics, nuclear energy, and a host of others ponder the facts of their own experience. Did they gain or lose in pooling their hard-won know-how with that of their co-workers? Was the parable of the loaves and fishes enacted all over again? The data from this revolutionary social experiment that has occurred under war's compulsion are in our hands. Perhaps we can use them to advance one phase of civilization the equal of a hundred groping years of peacetime evolution. What we make of this opportunity rests on our ability to apply the familiar tool of the scientific method to the unaccustomed subject of economic relationships.

Significantly, recent experience indicates that interchange of knowledge is justified by subsequent economic advantages. The trend in scientific publication has been toward such an increase, both in volume and in scope. The petroleum industry is especially noteworthy in this respect. Is it cause or effect that this industry has likewise proved one in which general advance in knowledge is particularly rapid, and in which many developments beneficial to all—and quite profitable to the industry—have been achieved? Liberality in publication of both basic and applied findings without question has been a vital stimulus in these advances.

Most of the progressive and successful industrial organizations now actively encourage their employees to write for technical publication. Remarkably enough, however, some of them have found that *even* with encouragement and with the additional strong personal incentive coming from the prestige involved in technical publication, too few papers are forthcoming.

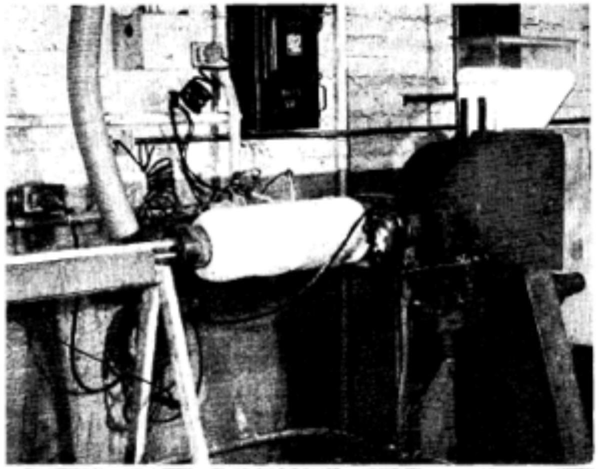
Is the individual at fault? Examine your own situation. First, acquaint yourself with the publication policies of your organization. You may find that you have been applying a censorship more strict than your superiors actually consider necessary or desirable. Then evaluate your work in terms of its broad technical significance. If it passes muster, reduce it to the written word. Today is the time for action if our hopes for tomorrow are to be realized.

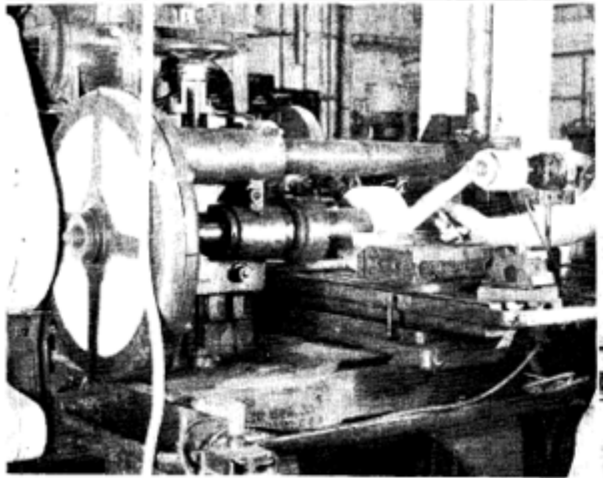
TEFLON, ANNOUNCED

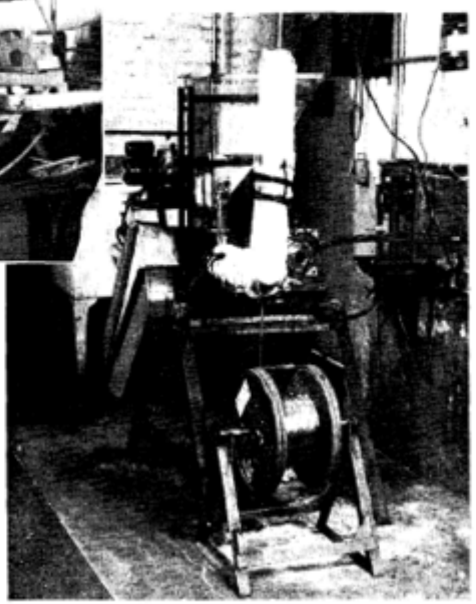
method in studies of the reactivity of fluorine in aliphatic compounds. More recently, Ruff and Willenberg (27) reacted fluorine with silver cyanide to obtain hexafluoroazomethane, which breaks down in an electric arc to yield some tetrafluoroethylene, among other products. Another method of preparation is by the pyrolysis of chlorodifluoromethane or bromodifluoromethane according to Downing, Benning, and McHarness (9) and Torkington and Thompson (31).

POLYMERIZATION

Polymers of tetrafluoroethylene were first disclosed in 1941 by Plunkett (24). Although the polymerization of various halogenated ethylenes had been studied for some time, there had been no indication previously that high polymers might be formed







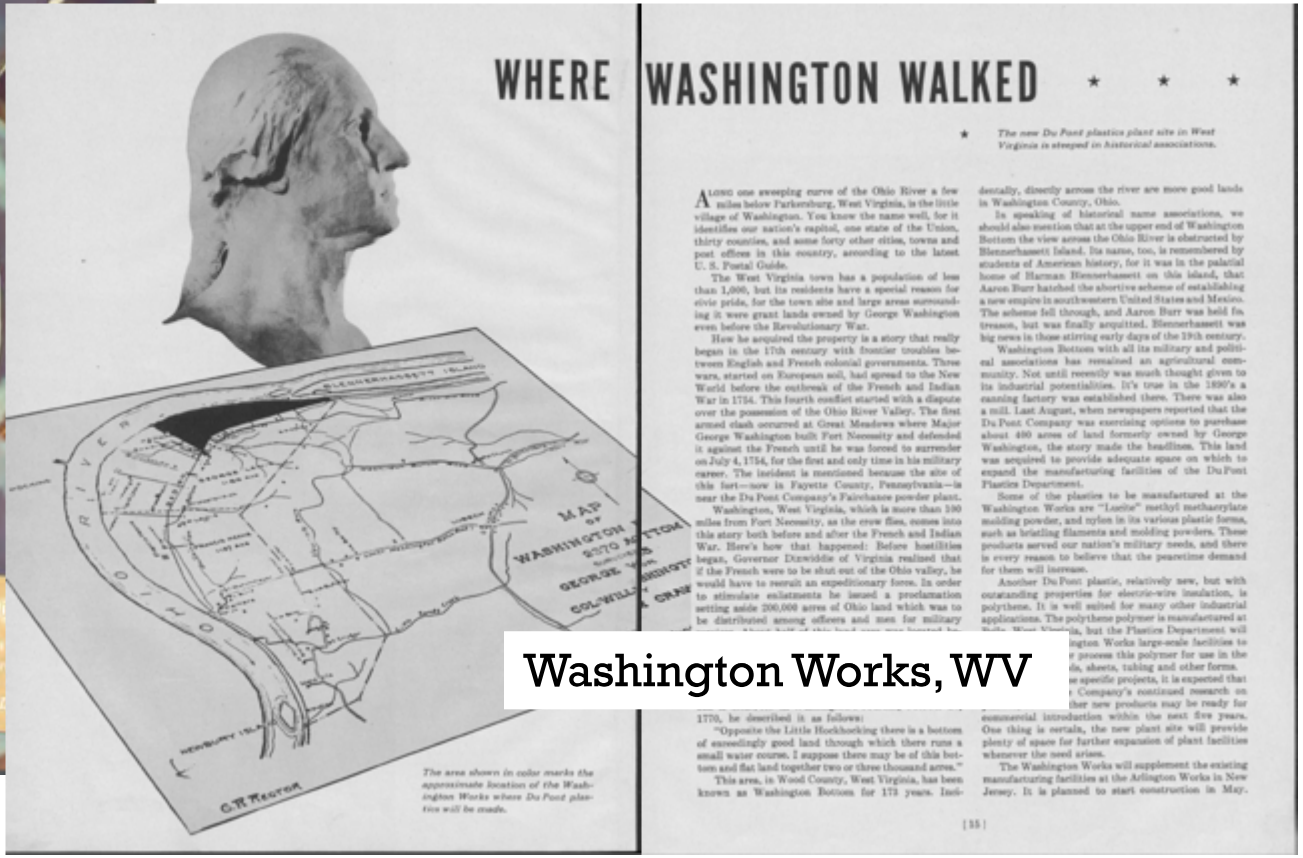
Manufacture of Polytetrafluoroethylene Shapes for Various Applications. (*Top*) Rods Are Produced by Extrusion in an Experimental Unit. (*Center*) Molded Cylinders Are Shaved on a Lathe to Yield Tape. (*Below*) Seamless Covered Wire Is the Product of This Operation; Bare Wire on the Spool at the Bottom Passes up Through a Vertical Extrusion Chamber Where the Plastic Sheath Is Applied. View on the Opposite Page Shows Products Fabricated of Polytetrafluoroethylene for Industrial Use.

Polytetrafluoroethylene is a new plastic being manufactured on an experimental plant scale. It is insoluble in all solvents tried so far and is not attacked below its melting point by any common corrosive agent except molten alkali metals. It withstands temperatures up to 300° C. for long periods without serious degradation and is not brittle at low temperatures. An outstanding property is its combination of low power factor and low dielectric constant. The principal current uses for polytetrafluoroethylene are as gaskets and packing in equipment for handling hot corrosive liquids and as electrical insulation, particularly at high frequencies and under strenuous environments. The plastic is being sold in small quantities for development purposes, in the form of simple shapes such as tape, sheets, rods and tubes, gaskets, and insulated wire.

Renfrew & Lewis 1946

AND PLANS FOR A NEW PLANT

May 1946



WHERE WASHINGTON WALKED

The new Du Pont plastics plant site in West Virginia is steeped in historical associations.

Along one sweeping curve of the Ohio River a few miles below Parkersburg, West Virginia, is the little village of Washington. You know the name well, for it identifies our nation's capitol, one state of the Union, thirty counties, and some forty other cities, towns and post offices in this country, according to the latest U. S. Postal Guide.

The West Virginia town has a population of less than 1,000, but its residents have a special reason for civic pride, for the town site and large areas surrounding it were grant lands owned by George Washington even before the Revolutionary War.

How he acquired the property is a story that really began in the 17th century with frontier troubles between English and French colonial governments. Three wars, started on European soil, had spread to the New World before the outbreak of the French and Indian War in 1754. This fourth conflict started with a dispute over the possession of the Ohio River Valley. The first armed clash occurred at Great Meadows where Major George Washington built Fort Necessity and defended it against the French until he was forced to surrender on July 4, 1754, for the first and only time in his military career. The incident is mentioned because the site of this fort—now in Fayette County, Pennsylvania—is near the Du Pont Company's Fairchance powder plant.

Washington, West Virginia, which is more than 100 miles from Fort Necessity, as the crow flies, comes into this story both before and after the French and Indian War. Here's how that happened: Before hostilities began, Governor Dinwiddie of Virginia realized that if the French were to be shut out of the Ohio valley, he would have to recruit an expeditionary force. In order to stimulate enlistments he issued a proclamation setting aside 200,000 acres of Ohio land which was to be distributed among officers and men for military

Washington Works, WV

1770, he described it as follows:

"Opposite the Little Hockhocking there is a bottom of exceedingly good land through which there runs a small water course. I suppose there may be of this bottom and flat land together two or three thousand acres."

This area, in Wood County, West Virginia, has been known as Washington Bottom for 173 years. Incidentally, directly across the river are more good lands in Washington County, Ohio.

In speaking of historical name associations, we should also mention that at the upper end of Washington Bottom the view across the Ohio River is obstructed by Blennerhassett Island. Its name, too, is remembered by students of American history, for it was in the palatial home of Harman Blennerhassett on this island, that Aaron Burr hatched the abortive scheme of establishing a new empire in southwestern United States and Mexico. The scheme fell through, and Aaron Burr was held for treason, but was finally acquitted. Blennerhassett was big news in those stirring early days of the 19th century.

Washington Bottom with all its military and political associations has remained an agricultural community. Not until recently was much thought given to its industrial potentialities. It's true in the 1890's a canning factory was established there. There was also a mill. Last August, when newspapers reported that the Du Pont Company was exercising options to purchase about 400 acres of land formerly owned by George Washington, the story made the headlines. This land was acquired to provide adequate space on which to expand the manufacturing facilities of the Du Pont Plastics Department.

Some of the plastics to be manufactured at the Washington Works are "Lucite" methyl methacrylate molding powder, and nylon in its various plastic forms, such as bristling filaments and molding powders. These products served our nation's military needs, and there is every reason to believe that the peacetime demand for them will increase.

Another Du Pont plastic, relatively new, but with outstanding properties for electric-wire insulation, is polythene. It is well suited for many other industrial applications. The polythene polymer is manufactured at Belle, West Virginia, but the Plastics Department will ... ington Works large-scale facilities to ... process this polymer for use in the ... ds, sheets, tubing and other forms. ... specific projects, it is expected that ... Company's continued research on ... ther new products may be ready for commercial introduction within the next five years. One thing is certain, the new plant site will provide plenty of space for further expansion of plant facilities whenever the need arises.

The Washington Works will supplement the existing manufacturing facilities at the Arlington Works in New Jersey. It is planned to start construction in May.

The area shown in color marks the approximate location of the Washington Works where Du Pont plastics will be made.

[15]

3M ALREADY SPONSORING SIMONS

COPY

A G R E E M E N T

THIS AGREEMENT made and entered into as of the 15th day of October, 1945, by and between The Pennsylvania State College, a Pennsylvania Corporation of State College, Pennsylvania, hereinafter referred to as "THE COLLEGE" and Minnesota Mining and Manufacturing Company, a Delaware Corporation, having an office at Saint Paul, Minnesota, hereinafter referred to as "MINNESOTA".

W I T N E S S E T H T H A T:

WHEREAS, THE COLLEGE and MINNESOTA are individually and mutually interested in the development of the chemistry of fluorine; and

WHEREAS, one means of promoting such development lies in the increase of useful knowledge of the chemistry of fluorine through research and experimentation; and

WHEREAS, MINNESOTA is particularly interested in that branch of the chemistry of fluorine relating to Fluorine-Carbon Compounds as hereinafter defined; and

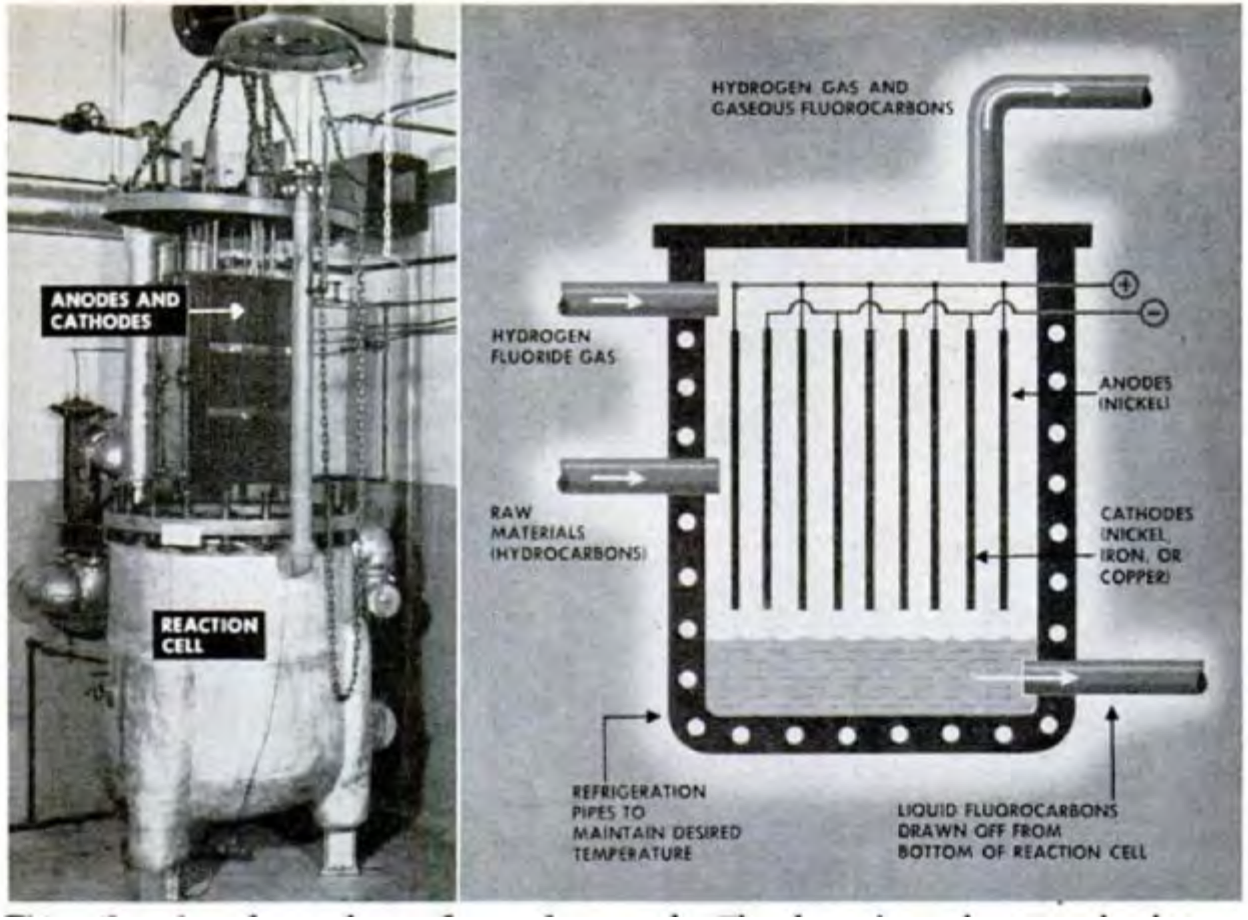
WHEREAS, since about August 1, 1943, MINNESOTA has sponsored a certain Program of Research (identified as Project No. 1474) at the laboratories of THE COLLEGE and under the direction of Professor Joseph H. Simons of the School of Chemistry and Physics of THE COLLEGE, Director of the Fluorine Research Laboratories (hereinafter sometimes referred to as "SI directed to Fluorine-Carbon Compounds, as hereinafter defined, and to methods, processes and/or apparatus for the production thereof; and

WHEREAS, MINNESOTA and THE COLLEGE are mutually desirous of continuing said Program of Research subject to the terms, conditions and provisions hereinafter set forth;

WHEREAS, since about August 1, 1943, MINNESOTA has sponsored a certain Program of Research (identified as Project No. 1474) at the laboratories of THE COLLEGE and under the direction of Professor Joseph H. Simons of the School of Chemistry and Physics of THE COLLEGE, Director of the Fluorine Research Laboratories (hereinafter sometimes referred to as "SIMONS"), directed to Fluorine-Carbon Compounds, as hereinafter defined, and to methods, processes and/or apparatus for the production thereof; and

Penn State Univ archives

3M PILOT PLANT



Popular Science 1949

POPULAR PRESS

Taming Chemistry's Hellcat

By MILTON SILVERMAN

New 'Magic' Compound Aided A-Bomb Output

By JOHN M. McCULLOUGH

Continued From First Page

day in a news release from Pennsylvania State College and in the current issue of the Scientific American, in an article by Dr. J. H. Simons.

Dr. Simons, 52-year-old native of Illinois, is professor of physical chemistry and director of the Fluorine Laboratories at State College.

In his article, Dr. Simons strongly infers the belief that a fluorocarbon's use in the uranium separation plant—prerequisite first step to the production of an atom bomb—was coincidental and of small importance beside the "entirely new domain of chemistry" which it unfolds.

SCOPE 'BREATHTAKING'

The scope of application of the new compounds—and the "many times" a million times a million chemical compounds which may be extracted from them (that's many times 10 to the 13th power, if you like that kind of mathematics!)—

ple was supplied for tests in 1941. The atomic bomb workers found that it resisted the attack of the reactive uranium hexafluoride, and so the new-born fluorocarbons were baptized as a military material. For reasons of military security, they were designated as 'Joe's Stuff,' (Dr. Simons' first name is Joseph).

The original, laboratory-scale method for combining carbon and fluorine, Dr. Simons explains, since has been supplanted by a much more efficient electrochemical process. A pilot plant employing this technique is now in operation in St. Paul, Minn., he says in his magazine article.

The flow of electricity through an electrochemical cell acts upon the "raw" materials—hydrogen fluoride and any one of a number of organic chemicals—so as to cause the fluorine in the hydrogen fluoride to replace the hydrogen in the organic material, thus forming a "fluorocarbon." The free hydrogen from both the fluoride and the organic compound escapes as a gas.

Milton Silverman (1949)
Taming Chemistry's Hellcat
Collier's Weekly

Front page of *Philadelphia Inquirer* (1949)

POPULAR SCIENCE

Reaction chamber for laboratory production of fluorocarbons at Pennsylvania State College looks like a sawed-off barrel. It holds ice and brine for controlling temperature of single electrochemical reaction cells. With this apparatus, experimenters in the school's Fluorine Laboratories at State College, Pa., have produced more than 200 sturdy fluorocarbon compounds.

Indestructible fluorocarbon plastic is tested by boiling in sulphuric acid. Rod at right, a du Pont product called Teflon, is unaffected; rod of ordinary plastic at left is badly charred.

Dielectric strength of disks of Teflon is tested under high voltages. Its high insulating qualities make the new material valuable as a nonconductor in radar and television equipment.

New Materials Won't Wear Out

Fluorocarbons from a little black box make everlasting oil, fireproof paints, and indestructible building materials.

By George H. Waltz, Jr.

Photos: du Pont, Penn State, Hubert Luckett for PS

REVOLUTIONARY, indestructible materials are flowing out of a magic black box in a small laboratory in central Pennsylvania.

The box is an electrochemical reaction chamber, no bigger than a large barrel. The laboratory is one of many on the Pennsylvania State College campus. The materials it produces are known as fluorocarbons.

From these materials soon will come improved fire extinguishers; fireproof paints, fabrics, plastics, and building materials; wire insulation that will stand up under extremely high temperatures; heat-resistant fluids for driving turbines; and lubricating oil for your car that will never wear out!

Fluorocarbons are the sturdy first cousins of hydrocarbons. Our food and fuels are hydrocarbons. They consist of atoms of hydrogen linked to atoms of carbon—the basic element of all living matter—to form chain and ringlike molecules. In the fluorocarbons, fluorine, the most active chemical element yet discovered, replaces the hydrogen in the molecule and is linked to the carbon atoms.

Physically and structurally, the fluorocarbons resemble the hydrocarbons. Chemically, however, they are vastly different. The hydrocarbons are chemical action; the fluorocarbons defy it. Whereas ease of combustion or burning makes the hydrocarbons valuable to us as foods and fuels, the chemical inertness of the fluorocarbons makes them ideal ingredients for tough, long-wearing products in thousands of different industrial fields ranging from power generators to electrical appliances and from automobiles to textiles.

Why, you are probably wondering, if the fluorocarbons are similar to the hydrocarbons in structure, are they so steadfastly stable and the hydrocarbons so unstable? Fluorine's characteristics explain the difference. It is the most active and tenacious element known (PS, Sept. '46, p. 134). Once it combines with carbon to form a fluorocarbon, it hangs on, defying any efforts to pull the molecule apart. The bond between the fluorine and carbon is so tight that most fluorocarbons will react chemically only under extremely high temperatures that would disintegrate any type of container.

The indestructibility of the fluorocarbons made them particularly valuable during the war. Early in the atomic project, for example, containers—crucibles and bottles—were needed to hold and store the extremely active uranium hexafluoride used in the process. Containers made of fluorocarbons provided the answer. Many of the workers around the nation's atomic piles today are protected by coveralls impregnated with indestructible fluorocarbon compounds.

The wartime fluorocarbons, however, were extremely costly. They were produced by a dangerous, expensive, and involved multi-step chemical process that made their use in

132 POPULAR SCIENCE

JANUARY 1949 133

1949

3M: "AT LAST… OUR 1ST REPEAT SALE"

The year 1950 was very significant, one of the major chemical companies came to us after the '49 ACS meeting and said, "We need a surfactant. Would you make for us the ammonium salt of a nine-carbon carboxylic acid, completely fluorinated except for a hydrogen on the far end?" We looked at it and had to say we couldn't, but asked if they would care to try an eight-carbon carboxylic acid with fluorine on the end.

WH Pearlson
J of Fluorine Chemistry
1986

At first they declined, they had technical experience that showed their compound worked and a theoretical basis for saying they needed it. We said that we could make the completely fluorinated acid and it was worth a trial. They tried it and they liked it, and, as a matter of fact, they are still buying it.

Now at last we had our first repeat sale. For the first time we had a customer out there who was going to buy the materials today, and next week, and, optimistically, next year even: we were in business! Actually, we had one fulltime salesman.

3M: "OUR FIRST REAL ENTRY…"

3. Fluorochemicals, announced in our 1950 Annual Report, have continued to find new markets with major U. S. companies. Semi-works production and sale of new 3M Fluorochemicals was announced late in 1951. This is our first real entry into the chemical business, and is a long-range program based on a unique and patented electrochemical process.

3M Annual Report
Minnesota Historical Society, 3M historical corporate records, Box 129.E.19.7B, Folder 15: New products division: chronology of division projects, 1940-1953.
Courtesy of **Evan Hepler-Smith**

POPULAR MECHANICS

"Just how this process works is still a mystery," says Professor Simons, "but the important thing is that it does work, and in a highly efficient manner."

(1952)

WITHIN THE PAST few months, chemistry—like a curious lad—has vaulted across the fence and started exploring a vast new field. Though the chemist knows little about this broad expanse, he's aware of its significance. He realizes he has leaped into a third dimension in chemistry and, dimly, he sees it's a dimension with truly staggering possibilities.

In the past the chemist's work has been divided into two broad fields—organic and inorganic chemistry. Traditionally, organic has been the more important and fascinating field, for it deals with hydrocarbons, the fuels and foods of our universe. Hydrogen and carbon eagerly combine with each other and with other elements to form a huge array of basic building blocks—from plywood and cold cuts to plastics and coal.

POPULAR MECHANICS MARCH 1952

WRITTEN SO YOU CAN UNDERSTAND IT

VOL. 97 NO. 3

By Clifford B. Hicks

Invisible gas, five times heavier than air, is poured from beaker to beaker. Balloon floats in it

WANTED—Jobs for a Trillion New Chemicals

81

IMPLICATIONS

Reckoning

What is the full fluorocarbon **legacy** of the Manhattan Project?

What is **archived** on site?

What is in the **archives**?

Responsibility

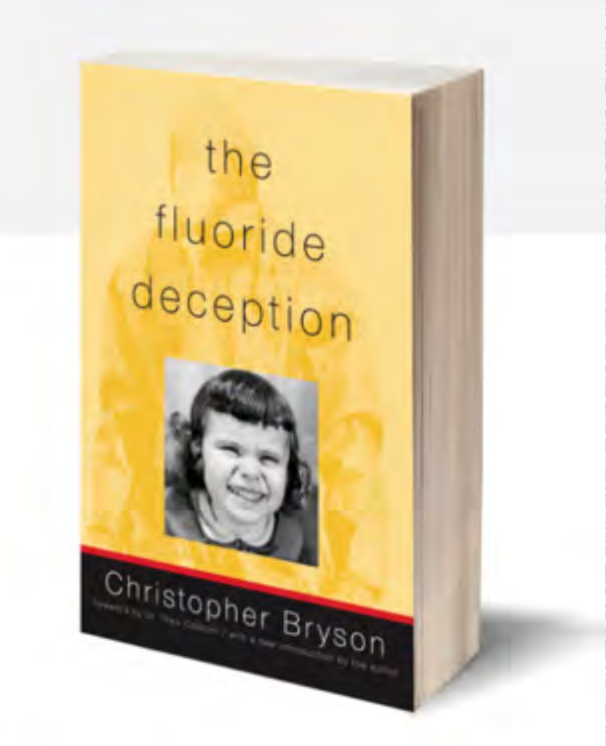
PFASs have **military** origins

R&D subsidized by **public money**

Funded the **proving grounds** for Teflon, ECF technologies and more, then developed by private companies

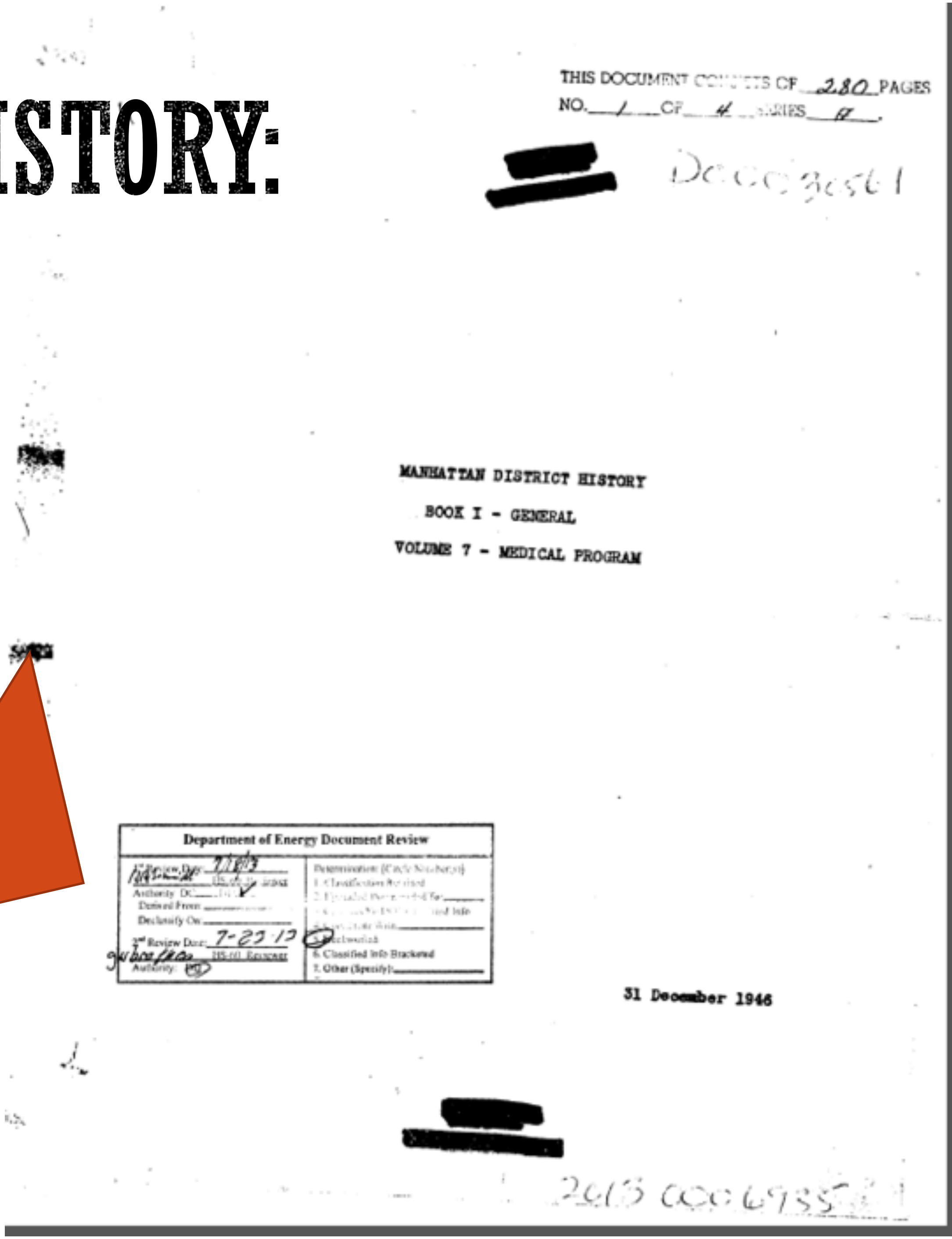
BRYSON DIPPED INTO MANHATTAN PROJECT DOCUMENTS,

STUMBLED INTO HOW MEDICAL DIVISION TOOK UP FLUOROCARBON RESEARCH



2004

MANHATTAN DISTRICT HISTORY: MEDICAL PROGRAM


THIS DOCUMENT CONSISTS OF 280 PAGES
NO. 1 OF 4 SERIES A.

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MANHATTAN DISTRICT HISTORY

BOOK I - GENERAL

VOLUME 7 - MEDICAL PROGRAM

Department of Energy Document Review

2nd Review Date: 7-23-13

6. Classified Info Bracketed

7. Other (Specify):

31 December 1946

[redacted]

Dated: December 1946
Declassified: DOE 2013
Via Wellerstein's Manhattan Project database

~~SECRET~~

[redacted]

Fluorine and the fluorocarbons in general were industrially new products and processes, and studies of their hazards and medical control had to be considered.

The liquids which were produced or used were the fluorocarbons, which are entirely new compounds, industrially, and are moderately toxic;

~~S[redacted] INFORMATION~~

~~SECRET~~

b. Liquids.

(1). Fluorocarbons. - These compounds are composed of fluorine and carbon and are primarily used as lubricants and coolants by the Manhattan District. These compounds (C_7F_{16}, C_8F_{16}, $C_{21}F_{44}$) were found to be moderately toxic to animals upon inhalation, but some of the intermediate products formed in the production of these compounds were found to be toxic to animals in concentrations varying from 70-500 parts per million parts of air. The animals exposed to toxic concentrations of these intermediate products of the fluorocarbons died apparently as a result of respiratory failure.

Time-bombing the future

Synthetics created in the 20th century have become an evolutionary force, altering human biology and the web of life

Rebecca Altman

Aeon Magazine (aeon.co)

January 2019

Sources, resources at:
www.rebecca-altman.com