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NEW MATERIALS FOR NATIONAL STRENGTH

Mr. Roger W. Fulling and Team

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Reviewed by Col E. J. Ingmire, USA on 17 January 1964.

INDUSTRIAL COLLEGE OF THE ARMED FORCES

WASHINGTON, D. C.

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NEW MATERIALS FOR NATIONAL STRENGTH

18 December 1963

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ARMED FORCES

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Reporter--Grace R. O'Toole

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18 December 1963

GENERAL STOUGHTON: Gentlemen: We are indebted today to the Du Pont Company for making available to us a team of distinguished scientists to talk to us about new and improved materials which are so vital for progress in this rapidly changing world in which we live.

You have read their biographies, so I will merely at this time welcome the team as a group and introduce the lead-off speaker, Mr. Roger W. Fulling.

Mr. Fulling.

MR. FULLING: Thank you, General. Good morning. Admiral Rose, Colonel McElwee, Gentlemen: I presume by loose definition that this would include some of my interloping, curious friends from the Pentagon who are in the audience today.

We at Du Pont are privileged to talk with you this morning about our favorite subject, Du Pont research and development.

Your Du Pont guest speakers are Dr. Robert Joyce, our Director of Research of our Central Research Department; Dr. Robert Cavanaugh, Director of Research for our Explosives Department; and Dr. Frank McGrew, Director of Research for our Plastics Department. I am from another large department, known as the Development Department. Later this morning you will have an opportunity to talk informally with these people.

A very brief look at the company organization chart, with a few remarks as to where we fit into the organization, may assist you in putting our remarks in proper focus. If you wish to obtain detailed information, Colonel McElwee has copies of charts and other data pertinent to Du Pont.

The Du Pont Company has over 232,000 stockholders, a Board of Directors which meets monthly, an Executive Committee, composed of the President of the Company, as Chairman, and eight Vice Presidents. This committee is the most important committee in our company, and it meets at least once a week. The Finance Committee, composed of the Chairman of the Board and eight other Directors, meets twice a month.

Du Pont is large. Our sales are in the magnitude of $2.5 billion, and, happily, they are rising. We have an investment of $3.5 billion, which represents an investment of over $37,000 per employee. It takes money to finance a chemical company. We have 81 manufacturing plants in 28 States and over 40 manufacturing plants in 10 foreigh countries. Currently an expansion plan for construction in the Un ited States and in foreign countries is under way. This program is estimated to cost in the magnitude of $400 million, and it represents some of the payoff resulting from our research and development programs.

Pioneering research is directed to research for new materials, products, and processes not presently developed in our business. Supporting research is that effort directed to the improvement of existing

processes and manufacturing technology. In the area of pioneering research we have some 1300 scientists with additional supporting assistants, with budgets in the magnitude of $61 million. In addition, there are $65 to $70 million being expended annually for supporting research activities.

Each industrial department, central research, engineering and developing, and medical has its own research divisions and laboratories. The technical activity conducted in these laboratories and the personnel in the laboratories are under the responsibility and direction of their department's Research Director.

The squares on the chart--and this is not indicative of the type of people in this activity--indicate the industrial departments which are known as the make-and-sell effort of the company. These are the people who make the money. These departments are headed by a General Manager who is the equivalent of a president of some other company and has complete autonomy for conducting activities leading to a satisfactory return on his investment in the areas of research, manufacturing, and sales. The yardstick we use in the Du Pont Company for proficiency is the return on investment.

Doctors Cavanaugh and McGrew are Research Directors for the make-and-sell departments for their respective areas of interest.

Now, the circled departments--and I do not mean that they don't know where they are going or that they are big wheels--are the auxiliary or staff departments and, as indicated by their names, are engaged in specialized functions which are directed to assisting the make-and-sell departments

in creating new business and increasing their return on investment.

Dr. Joyce represents Central Research and I, Development.

Very briefly, the Development Department is a staff department created to assist corporate and departmental managements in special studies, long-range planning, the creation of new business ventures, and liaison with the Government.

The Central Research Department has two major functions: First, the creation and execution of fundamental research in the broad field of science, not restricted to any particular department interest or product line, and, secondly, the administrative housekeeping for the experimental station located in Wilmington. The Experimental Station is our major location for the conduct of pioneering research.

This will suffice in the way of introduction to our subject of Research Materials, and we are looking forward to our informal discussions with you, at which time, Colonel McElwee tells me, you sharpen your spears.

Dr. Joyce, Director of the Central Research Department, will now discuss fundamental research, and he will be followed without further introduction by Dr. Cavanaugh, Explosives Department, and Dr. McGrew, Plastics Department.

DR. JOYCE: There is a great deal of talk in the public press these days about fundamental research. I think this term means a great many things to different people. For the purposes of my discussion I would like to define it as the exploration of the physical sciences in search of

basic knowledge and without any specific commercial objective.

This kind of research is typical of what is done in a great many of the American universities. There is a substantial amount of it done in many government laboratories, and it is done in varying degrees and for a number of reasons in a number of industrial corporations. The Du Pont Company does it for just one reason, and this is because of a deep-rooted conviction that this kind of research can lay the basis for new products that are going to diversify our business, that are going to improve the return on the company's investment, and that are going to have an impact, a favorable one, on the national economy, and that are going to assist in the national defense potential. We have no interest in doing this kind of research as window dressing, as a sop to a certain selected group of scientists, or for any other reason. The kind of management which has maintained the earnings directed to the Du Pont Company would not hold still for this kind of research unless it were convinced that it was in the Company's interest.

As Roger said, the Central Research Department, which I represent, is primarily responsible for this kind of work in the Du Pont Company. We do not have a monopoly on it. This kind of exploratory work is done in some degree in each of the Company's Industrial Department's research divisions. But they have plenty of other things to keep them busy, whereas exploratory work is the primary business of Central Research.

We have today about, roughly, 100 working scientists engaged in this kind of work in the Central Research Department whose efforts are also

supplemented by about half that number whose primary job is to take the first steps in trying to capitalize on the findings that are made by these basic explorers.

Now, in our Department, this fundamental research effort comprises explorations in a substantial variety of the physical sciences. Perhaps the keystone of our effort is exploratory synthetic work in organic chemistry, organic metallic chemistry, and inorganic chemistry. We have in addition basic research in molecular structure, studies of energy transfer and liquid solids, solid state physics, and exploration in a number of areas of biology.

I said earlier that the Du Pont Company would not engage in this kind of work if it were not convinced that it would pay off. This feeling is buttressed by what has gone on in the past. The Du Pont Company today is shaped to a substantial extent by commercial developments that have arisen out of precisely this kind of exploration in the past. Examples of some of this, which I think are familiar to most of you, include, of course, nylon, which is the one we like to point to and which everybody recognizes, and which arose from an uncommitted exploration into the properties of high molecular weight condensation polymers.

The concept of a synthetic fiber and an industry based on it didn't arise until 4 or 5 years after the inception of that exploratory program. Teflon and its neighbors, and the whole fluorplastic industry, as a matter of fact, stemmed from fundamental explorations into properties of small molecules containing large quantities of fluorine. The substituted

urea herbicides which are widely used today in industrial, agricultural, and, I gather, to some extent in military uses came out of an exploration of the relationship between molecular structure and biological activity.

I would like to spend the remaining few minutes on a brief discussion of two or three things that have emerged recently from our exploratory research to give you an idea of some of the things that we think may be on the horizon.

First off I would like to mention an inorganic material which we call KT for short but which is the abbreviation for potassic titanite. This is a relative of the familiar white pigments containing dioxide, but it has the very interesting property of crystallizing in very small fibers with a high aspect ratio. It is possible to prepare this material with fiber diameter in the range of one micron. It has a nice, high, refractive index and that, coupled with its carefully controlled particle size, makes it one of the most effective scatters of infra red, or near infra red, that man has ever seen.

In consequence of this, we believe that it has unusual potential as a thermal insulator, and it is being explored and investigated in a number of the Armed Forces laboratories because of this property today. It can be utilized continuously at temperatures as high as 1100° C., and in the range of, say, 500° to 1100° C. it has a thermal insulating capability that surpasses that of any other material we are familiar with.

Second, I'd like to mention a new metallic alloy that attracted our attention when it became apparent that it could be held at temperatures

on the range of 1500° C. for hundreds of hours with essentially no apparent degradation. This is in air. There are plenty of materials on which you can take up the high temperatures for short periods of time, but a material which can stand oxidizing conditions up to 1500 is something that we had never seen before.

This material has got transfer structure strength on the range of about 27,000 PSI at room temperature and still maintains a respectable transfer structure strength at temperatures as high as 1500° C. This again is being explored for a number of military applications in several of the Defense laboratories.

Finally I'd like to touch briefly on one of the recent outgrowths of our exploratory work in biology. I think you are familiar with the fact that there are a number of mechanisms in nature for the fixation of molecular nitrogen from the atmosphere into useful forms of nitrogen. One of the things that perform this function are a number of types of bacteria. We have succeeded in isolating from one class of soil-growing bacteria the enzyme system that in the laboratory can perform the whole operation of converting molecular nitrogen into ammonia. This is the first time this has been done in a system that is completely free of living cell materials.

We are working today to try to isolate, identify, and characterize the specific enzymes that are responsible for this remarkable transformation. We have no idea, really, where this is going to take the Du Pont Company or anyone else, but we are firmly convinced that, if we can get our hands

on these enzymes and find out what they are, we ought to be able to convert this process of nitrogen fixation into uses to which man has never been able to put it to before. I hope some of them may have a benefit and influence on the Du Pont Company's earnings.

Thank you.

DR. CAVANAUGH: Gentlemen, I'd like to talk about spin-off. This has been much in the news. I want to talk about it generally a little and then I'd like to get down to some of the specifics, and particularly one thing.

I believe that there are reasons to be optimistic about the prospects of spin-off from research that is financed by the Government in industry, in the public sector. I believe, though, that it will come only from a very small portion of this very large budget. I believe that it will come from the type of work that is being done in government similar to that just described by Dr. Joyce. I think it is not likely to come in any substantial amount from the developmental type of activity that is costing so much in this total government-funded research effort.

In Du Pont we plan the work, as Dr. Joyce has indicated, and we expect it to produce spin-off. We have a very hard time obtaining this spin-off, even though we are working in, I think, a well organized manner and very intensively along lines that I think are particularly favorable to spin-off and not to some other objective.

This will come from the Central Research Department of Du Pont to my Department, to Dr. McGrew's Department, and to all of the others.

Because of some of the work that we are doing that is exploratory in nature in our Industrial Departments and in mine, for example, there are perhaps 25 people who are working similarly to the 100 people that Dr. Joyce spoke of. The 150 or so other people in my Department are doing the developmental work, and the record would indicate that they are not likely to produce information which will result in spin-offs in other departments of Du Pont. The 25 men, however, from past performance, men doing this type of work, are likely to come up with things which will be helpful to other departments, and those other departments will obtain spin-off.

Now, it is my conviction that there is right now and there has been a very large amount of spin-off from industrial research of this exploratory type into uses that are important in the Department of Defense. For example, during World War II we were asked to manufacture a plastic explosive. As a matter of fact, we were given the formula, the process, and everything we needed by the British. But it was quite clear that this material was too crumbly and just was not physically appropriate for the purpose intended.

So we turned to our background in the manufacture of gelatine dynamite, something which has been around a long, long time, and we formulated and produced as an explosive something that was more effective than the standard composition C and that furthermore had the physical properties that made it practicable.

We have now extended this work recently in our research to produce

a sheet explosive which is a sort of gelatine dynamite but is one that is far superior to the military plastic mixture that we had 20 years ago. The very latest thing on this front is that we are combining some technology of the Plastics Department involving teflon resin to use it as the binder for high explosives which are of very high density and will produce detonation head pressures of almost double that which we can get by other means. These I think are promising leads for military application.

Now, there are some other potential spin-offs that I want to mention specifically and, because I gather that you will be about equally Army, Navy, and Air Force, I think I'll give you each one. We have gelatine dynamite, as I mentioned before, and we have for many years made a variety for use in seismograph exploration for petroleum. We went from there, along with the petroleum industry, who wanted to explore offshore, to a nitromon WW, which we call it. It is a non-nitroglycerine blasting agent in a watertight tin can, and it is dropped over the side of a ship and fired, and the echoes are recorded and the data are interpreted in terms of where the oil is probably to be found.

We've gone from there, and with our own funds turned this thing sideways, and we are now convinced that we can obtain echoes that would be useful in a submarine warfare. We have done some work under a Navy contract. Our first demonstration of this was in, say, the laboratory. We've carried it through a developmental stage indicating technically the feasibility of scaling it up, and the thing has now been shelved for lack

of interest in the development of an anti-submarine warfare system.

For the Air Force, the Central Research Department, a few years--I guess it is now--ago got a lead in the field of boron-hydrogen compounds. The materials which they were able to make are new. They are arrangements of the boron and hydrogen atoms into new molecular structures. They are capable of salt formation and we have made the hydrogenian salt and we have found that it is compatible with hydrozine, so we think that we have here a potential monopropellent.

There are two interesting properties. The interest is in the fact of their being simultaneously present. One is that these are permanently amicably unstable. The second is that they are remarkably stable physically. This is, of course, just what we want.

We have found, though, apparently very little interest in carrying it farther, but we are continuing to do a very small amount of work pretty much on our own to see whether it really is as good as we think this ought to be as a propellent.

Now, for the Army--and this is the one that I would like to detail a little bit because of a recent announcement which we have made in the Explosives Department that we are about to commercialize a piece of spin-off from our own exploratory research. For many years, of course, we have looked for new uses for explosives.

You have heard about an explosive forming of metals. We gave this up almost 10 years ago, having spent several hundred thousand dollars, because we were unable to find a way that this would make money for an

explosives manufacturing company of the Du Pont type. We think that it will continue--it has, actually--to be useful to a minor extent in the metal fabricating companies. But we are out of it.

We are continuing in a small way to commercialize the use of explosives for the hardening of Hatfield steel. This, of course, is very readily work hardened and we can work it with explosives quite effectively. This is commercial now for the hardening of railway track points--switches, crossings, and so forth.

Out of these two, we had difficulties with, for example, the work sticking in a metal female die and we had difficulties in hardening where we were using a shim metal which we propelled against the work in order to hammer it more effectively. In each case we found that the flying metal tended to stick here and there to the target. This was an annoyance. Of course, we wanted to get work out of the die, and of course it was an annoyance on the track work, because we had to wire brush and get the little stuck patches of shim away from there.

But one of our people said, "Let's turn it around the other way. Let's put one sheet on another sheet and get the patches to be large areas." This has now proved to be possible.

(Slide) This is a 20-foot by 7-foot, 12-ton, clad assembly. It is made up of 3/16ths inches-inch of 304L stainless on 4 inches of A-212 steel. That's coming directly from the explosive cladding area. It's not being treated.

(Slide) This is a blow-up, 150 magnification, of the bond between

stainless on the top and steel on the bottom. The patches in between are material that obviously has been molten and its composition--in the terms of--is a mixture of the two. In one diameter of a probe you go from the composition of the stainless coming in one direction , or the steel coming from the other, into the composition of the mixture, (indicating) from here to there or from here to there.

(Slide) This is a vessel which is 1/8-inch nickel clad to 1/2-inch A-285 steel. It is 4 feet in diameter and 8 feet long.

This is a vessel of 3/16 Hasteloi C on 1-inch A-212 steel. It is 3 feet in diameter and 6 feet long.

This is a 4½-foot diameter 8-foot long shape of 1/8-inch 55-A titanium on 7/8-inch A-204 steel.

We have as the result of this explosion cladding a material which has uniform composition and thickness, and these are not appreciably affected by the explosion. The physical and metallurgical properties of the components are unchanged. The fabrication qualities of these clads are very good. The bond that we obtain is of high integrity, and we have had better results in fabricating these clads than we have been able to get with hot-rolled, bonded materials.

As to the range of materials we can handle, these cover almost any metal or alloy and include the dispersion hardened metal systems.

I will be glad later to become more specific. I understand there will be some smaller group discussions, and I'll be glad to answer questions about this. We are entering this business and we wonder

whether there may be applications for the Army, for example, in armor.

DR. McGREW: I shall talk to you about new materials based on synthetic organic high polymers and in the course of that speak broadly about Du Pont's research in the field of synthetic polymers.

This is an activity that extends far beyond my own make-and-sell Department. In fact, it includes more than half of the 12 departments that were shown on Mr. Fulling's chart. Actually, about 70 percent of Du Pont's sales income is for polymers made by Du Pont. That means that in this year that class of materials will bring in roundly $1.75 billion.

This business is supported and advanced by about $100 million annually of company money and technical effort. This domination of polymeric materials in our business is of long standing. It has in fact prevailed since the origin of the modern company, which I will date at 1902, when Du Pont organized an industrial research laboratory, the first of its kind in the Nation.

The polymeric materials business has evolved through distinct stages of technology and of commerce. First this business came of age in the period approximately 1900-1930 with products for a wide variety of uses, of which I would mention as examples paint, plastics, films, and fibers, that were based on chemical modifications of naturally occurring polymers, such as cellulose from wood and cotton.

The second stage or period I date from 1930 to about 1952. This saw new products based on wholly synthetic materials--the coal, air,

and water type, if you like--introduced for each and every principal use that was already commercial on the semi-synthetic basis. The obsolescence of the first type by the second type is well advanced at this point in time.

In what I believe to be the third stage, beginning in the late forties--this is a stage, as you will note, that began really before the second phase had ended--the second-generation products with improved properties were beginning to be put into play, partly to supplement and partly to replace the first-generation synthetics.

Right now, the hottest battlefront in this introduction of second-generation products, this invasion of the established by the novel, is the introduction of materials to withstand high-service temperature. I will speak about four of these in different use areas, of which the first three are all based on a single chemical structure, the polyimids, which has resulted from 10 years of research. These three are polyimid in the form of film for capacitors and electric insulation in heavy-duty motors, polyimid in precision shapes for use in pumps, compressors, jet aircraft engines, and devices for grinding carbide machine-tool bits, and polyimid wire enamel, an impregnating varnish, which performs important services in heavy-duty electrical applications.

(Slide) Now I should like to show you in perhaps rapid succession some slides that recite the outstanding characteristics of these polymers as a class.

Thermal stability is the primary one of interest, but, as you see,

there are some others of significance.

(Slide) This is a relative chart showing the much higher temperature at which deformation occurs than with plastics available today--high dialectric strength, low-loss arc resistance.

(Slide) Now, this slide shows that while a polyimid does lose strength as the temperature goes up--all materials do eventually, of course--the polyimid actually surpasses the strength of pure aluminum at temperatures about 300° F.

(Slide) This slide shows some polyimid film which we have dubbed H-film draped over a red-hot bar in a zero strength measurement. H-film fails under this load at about 800° C., where aluminum would fail at about 500° C.

(Slide) This slide indicates that SP polymer can also resist breaking while undergoing exposure to very high temperatures.

Now, these last three slides indicate that polyimids will not melt or burn away when exposed to extreme temperature conditions for short periods of time. They are therefore a large improvement over existing plastics. Of course I can't construe this to mean that they will stand such exposures indefinitely. In long-term tests we believe that exposure to air at 250° C., which is 500° Fahrenheit, they will last 10 years or longer before their properties are significally changed. No other existing material comes even close to this performance.

I will now show some applications of the polymeric speed.

(Slide) This pictures veins used in light-weight, high-speed

refrigeration compressors for military application. An experimental integral motor and compressor using such veins has been built that is only 1 cubic foot in size and yet develops 10 tons of refrigeration capacity. It has passed 6,000 hours of continuous use testing at Fort Belvoir.

(Slide) This pictures ballbearing races for use without lubrication at temperatures up to 370° C–700° F. According to the Naval Air Materials Laboratory, these outperform all other constructions.

(Slide) Here are piston rings for non-lubricated compressors.

(Slide) These are diamond grinding wheels used for shaping carbide tool bits. The resin holding the diamonds is SP polymer. In the stage of preliminary market testing now these are showing quite consistently 2½ to 4 times the efficiency of the best commercial diamond wheels, and we attribute this superiority to the thermal resistance of the binder.

(Slide) Here are some new wire constructions using polyimid H-film. Constructions of these kinds are being used in the SATURN booster at a saving I have seen reported as 400 pounds of weight, mostly through the elimination of substantial amounts of metal braid that would otherwise be required.

(Slide) This pictures H-film insulation wrapped on heavy-duty traction motor windings. As soon as enough film becomes available the manufacturers indicate that they wish to switch to this construction.

(Slide) This Bendix generator armature is based on pyromel-coated glass-fabric slot liners and coated magnet wire.

(Slide) Here is the stator for the same generator. This was the

first to be insulated completely with the polyimid system. It is designed for high performance supersonic aircraft delivering its full rating of 15 KVA up to 65,000 feet altitude with minimum blast air because it can operate at a temperature as high as 250.

(Slide) Now, the second new polymer in its initial stage of commercialization is a high-temperature nylon trademark Nomex and is being made available as a fiber for textile and paper uses. This shows its retention strength for long periods of time.

(Slide) Here are some typical properties of paper. Without going into detail I can say that these make it especially useful in electrical situations where present papers would char and disintegrate.

(Slide) Here is a parachute that has been packed in normal fashion and then exposed to a test of oil-fed fire. It is obviously not usable.

(Slide) This is a parachute which has been enclosed in a Nomex cover. After it is subjected to the same test it is still usable.

(Slide) Finally, here are two Navy flight uniforms. It is estimated that pilots in the regular nylon uniforms would have suffered very severe burns, probably fatal, where a pilot in a Nomex uniform would have suffered far less.

I have had too little time to talk about heat-resistant polymers for other uses, such as elastimers, adhesives, and lubricants. Let me say it is our company intention to make comparable advances in service temperature and use characteristics in those fields.

The full impact of these materials on our military and industrial capability will take years more of development but I believe the examples

that I have suggested will suggest that this influence may become considerable.

I thank you and, speaking for my colleagues, we all thank you for the opportunity to unveil as many of these prospects that excite us today.

COLONEL McELWEE: Gentlemen, our panel are ready for your questions. It is not necessary to address your question to an individual.

QUESTION: This really is for Dr. Cavanaugh. You talked about the explosives cladding. Do you use the explosive method where you blow inward from the outside or are you blowing from the inside out of the pipes?

DR. CAVANAUGH: The pipes actually were made in the flats. They were formed into the tubular shapes. We can, though, clad in inside or outside of a tube. We need one to act as a scimitar.

STUDENT: Do you use sheet type explosives?

DR. CAVANAUGH: We use a layer of explosives, yes. It varies, depending on the nature of the metal. The elements of criticality are the distance between the two sheets as we set up the shot. The weight and the nature of the explosives are different depending on the metal we are attempting to accelerate. The cladding is the result of the collision of one plate with the other.

QUESTION: This is for Dr. McGrew. I am curious, Doctor, as to whether Du Pont sees in the near future competition with the copper and iron products in household plumbing installations— the plastics competition.

DR. McGREW: The invasion by plastics of the household plumbing field which has been occupied by metals is well under way right now. Plastics on the market today are adequate for the job.

MR. FULLING: May I say something along that line? The Du Pont Company, as part of our new ventures, is very much interested in building materials for all areas of construction--housing as well as industrial. In the future you will see more and more use of chemical-oriented materials, not just plastics but others, in your homes. This is one of the new ventures that I mentioned to you that we are taking a good, hard look at and that we are spending millions of dollars on and endeavoring in the near future to commercialize.

QUESTION: I am interested in knowing just what proportion of your total annual operation is devoted to research--the cost of your staff. Of this research can you tell us what proportion is industry supported and what proportion is government supported? Is there any trend of any change in the ratio?

MR. FULLING: I'll take the one on the ratio of industrial support versus the military, and the trend. Historically the Du Pont Company has believed and we continue to believe that, if research is of interest to us long term, we should do it with our own money. This is our policy today and it has been for many years. This does not mean that we turn our backs to government research. We don't. We are just as patriotic as you gentlemen. We have our position in the American economy as well as the defense economy. However, we believe that we can do a better job

by using our money in those areas that are not specifically directed to defense or to atomic-energy work.

Now, at the present time we are spending for Department of Defense activities on an annual basis in the magnitude of $2 million a year. The face value of the contracts which we have for the Army, Navy, and Air Force is in the magnitude of #8 million, but we are not spending at the $8 million rate.

As a corallary to the research that we are doing, some of my colleagues mentioned to you that our research materials are getting into the military pipeline by way of the research laboratories of the military. When we get a research material which we think is of interest to you, or we don't know whether it is of interest to you, but we think it is something which should be brought to your attention, even though we do not know what it would be good for, we take that material and the characteristics of the material to the military laboratories--Wright Field for the Air Force is one of the places we go, and we go to Picatinny.

Some of the work on the Nomex, which you gentlemen may know as the HT-1, was done by the Navy at Johnsville.

So, Captain, we've got $8 million in research and development contracts. We are spendikg about $2 million a year.

Now, Frank or Bob, do you want to pick up this other one on the commercial aspects?

DR. McGREW: The total tap taken for our efforts is about 5 percent of sales, of which four-fifths, I suppose, is spent by the make-and-sell departments.

MR. FULLING: I mentioned earlier that our pioneering research is in the magnitude of $61 million a year. Then, in addition to the pioneering research, the supporting research is in the magnitude of $65 to $70 million a year. In some people's definition, this would be considered research. We call it supporting research and development work.

QUESTION: I notice that all of you are about 50 years of age, have had 30 years with Du Pont, and are chemists. My question concerns the conventions or spirit life in American industry that the Du Pont Company has been accused of. Do you have a program such as that of the Bell System, for example, of broadening your men like the Bell System does?

MR. FULLING: Well, first off I'd like to correct something. I am not a chemist. I am a mechanical engineer. We have a very active program in the Du Pont Company on which our company is built, and that is the training of people. Our program is referred to as cross-fertilization of people in all jobs, all disciplines, at all levels. We transfer people from one job to another just as you people do in the military. We have all types of training programs.

Our training in Du Pont starts from the first day on which you are employed and lasts until you retire. The training programs are not called training programs per se. Actually they are on-the-job training, they are supervisory training, they are administrative training, they are training in business, or they are training in world affairs.

All of this is going on continuously in order to prepare people to take on additional responsibility. The majority of our people in Du Pont Company, particularly our technical people, are employed right after they leave college, either at the graduate or undergraduate level.

Now I'll let one of the chemists say something.

DR. JOYCE: I can go even further than that. Frank and I studied with the same man, the same professor, but he taught you that an organic chemist can do anything, and we still believe it.

DR. CAVANAUGH: Rog, I think you should send these people a list and the backgrounds of all the directors of research at Du Pont.

MR. FULLING: Let me carry this a step further. Bob Cavanaugh, for example, while he is a research man also has had practical exposure to our Company's business. He has been in our laboratories, he has been in our plants. He had a great deal to do with starting up the explosives plants for you gentlemen during World War II. To be a little personal, he limps because he got a little too close to his work.

You will find that all of our research people have had exposure to more than one type of activity, and no two of them are alike.

QUESTION: I couldn't help but notice that you gentlemen very modestly didn't mention that you designed and built Anburg and made the first atomic bomb, and later designed and built Savannah River for the H-bomb.

MR. FULLING: I think I heard of that somewhere along the line.

STUDENT: My question relates to atomic energy and its industrial

application. Drawing on your very considerable knowledge of that field, are you trying to make any use, such as on the radiation of materials, for atomic energy?

MR. FULLING: Bob, how about talking about the work you have done with your accelerator, and what Vic is doing.

DR. JOYCE: Of course, first off let me say that the people in our Atomic Energy Division are not oblivious to these possibilities. We have, however, at the Experimental Station, four accelerators today. In atomic energy terms, these are fairly low-energy jobs, but we have done and still are doing a fair amount of exploratory research on the effects of radiation in the range of 2 to 10 MEV on a variety of materials, both with respect to determining the extent that they may be degraded and also the efforts to find ways of improving them.

MR. FULLING: It happens that I was talking with Lum Squier yesterday about this very matter. As you know, there is a conference being programed now for April, I believe, at Georgia Tech in this particular area. Mr. Tremmel of AEC is very much interested in this, along with NASA. The Du Pont Company plans to participate in this discussion of the possibility of peaceful uses of atomic energy. There is potential.

DR. JOYCE: I might add to that, Roger. Our Textile Fibers Department has a synthetic fiber under evaluation in the Quartermaster Corps today that is a modified fiber in which high-energy radiation is used as the key step.

MR. FULLING: We are working with Natick on this, on some of our nylons.

QUESTION: My question deals with organizational concepts for research and development. I recognize that your divisions work around the development aspect and you concentrate obviously on putting in each division what it needs and requisitions.. What kind of alternatives have you examined in terms of centralized versus decentralized organization that have led to where you are now, with, say, 25 people versus 150 people?

MR. FULLING: Initially, and with deference to Bob Joyce, the Central Research Department was a part of the Development Department, but, as the Company diversified and as the Company grew, the management of the Company realized that research was something that should be pursued by research people and not by business-minded people. So, as a result, in, I think, 1910 or 1911, what is now the Central Research Department was split off from the Development Department.

DR. JOYCE: I'd like to follow on that. I saw a copy of a letter written by a top Du Pont executive back in the early 1920's in which he said, "If you are going to do research with the aim of developing new materials, it is absolutely imperative that you insulate your research people from having to deal with the day-to-day problems of running a business." In a sense that is the charter of the Central Research Department.

Now, for a number of years back in the twenties, the Central Research Department was just about the research of the Company, not exclusively but largely so. It is only since the late twenties and the early thirties that the development of research and development divisions as as integral

parts of our manufacturing departments became a reality.

So this thing has really grown up within the confines and within the framework of the broad Du Pont Company organization. I suspect that people many times have asked themselves, "Is this the right way to do it?" I don't know that there is a right way. I think the company management must like the way it works pretty well. It seems to operate pretty effectively.

STUDENT: My specific question is: You completely insulate your basic research people, so why not insulate them all in the Central Research Department instead of having 100 in one research area and 25 in another?

DR. JOYCE: Well, you want to watch out about how completely you insulate them. We don't try to insulate them in the sense of having them oblivious to what is going on in the Company at all. What is really meant by that phrase is that you are protecting them from being dragged in to put out fires.

MR. FULLING: Frank, you've got some of each in this. You've got laboratories spread out.

DR. McGREW: I think the virtue of the scatter we have in pioneering or exploratory research is that it has maximized the total exposure of the research people to the physical and particularly the technological world that our make-and-sell operation represents and communicates with.

DR. JOYCE: Let me add one other thing. There is a great deal of cross-communication between research men in the various parts of the organization. Fellows in our Department will speak to fellows in Frank's

Department or in Bob Cavanaugh's, and there is no red tape to go through to do that. If one of our research chemists wants to talk to a fellow in plastics he just goes and does it. There is a complete exchange of reports back and forth among them, and there is also an exchange of personnel both temporarily, for specific job purposes, and on a permanent basis. So you tend to enhance the exposure that Frank alluded to by a number of mechanisms.

MR. FULLING: The Experimental Station received its name, and we have never changed it, in spite of pressures, as the result of doing experimental work in explosives in the old ballistic laboratory. At the Experimental Station there are laboratories of each of the industrial departments as well as Bob Joyce's laboratory. Each of the industrial departments is doing pioneering research in its particular field of interest. In addition, the industrial departments have laboratories at some of their manufacturing operations. Most of these laboratories are directed to supporting research, although the oldest industrial research lab in the country, continuous, is that Eastern Lab of the Explosives Department, which is across the river from Wilmington.

QUESTION: Since Nebraska is so well represented this morning, what is it doing in relationship to water conservation and pollution control. I refer specifically to chemicals which are harmful and get into drinking water and the like.

MR. FULLING: The Du Pont Company and the chemical industry--and I can speak for only the Du Pont Company--have been leaders in waste

abatement. We realize that there are effluents emanating from our chemical processes that are not good for our streams and for our communities. For many years we have taken the lead in putting in sedimentation basins. We have put in mechanical equipment. We have put in electrolytic equipment for knocking out sulphuric acid fumes, for example. We have put in water and steam condensers to handle certain of our fumes. I don't have my piece of paper here, unfortunately, to tell you the millions of dollars that are being spent every year in this particular area, not only by Du Pont but by the entire chemical industry. The Manufacturing Chemists' Association right now has this problem as its No. 1 program on abatement. I think that General Decker will be very pleased to have someone from his group come and talk to you about this.

One last thing. We operate by the project system in the Du Pont Company. There are no free rides. Everything we do is on the project system, very similar to your line items, only not quite so rigid. But, when we put in a program to build a new plant or to make a plant improvement, one of the questions that must be answered by that department manager to the Executive Committee is: What wastes will emanate from this process and what will be done to correct the dispersal of that waste? This is the No. 1 question and it must be answered in every project.

QUESTION: Do you feel that your research might assist the military if it was not hampered by security restrictions of needs to know?

MR. FULLING: Very definitely so. We are among friends. It varies

from service to service. This is hampering one of our very important programs right today. All three services want and need this particular research but one of the services has put such security restrictions on it that it is stifling the use of it.

DR. JOYCE: The problem you face, you see, is that an awful lot of our stuff is not done under contract, and one of the first questions these fellows ask you is, "Well, what's your contract?" And we don't have one.

MR. FULLING: It so happens, Captain, in this particular instance that I'm speaking of, that the primary material that is used in this program is a Du Pont product which is commercial. You can buy it anywhere. So we can't understand why there should be this security wrap on it.

ADMIRAL ROSE: Whom have you gone to in the five-sided building over here to get this straightened out? There are people who could take care of that. You can go to the Director of Research and Engineering.

MR. FULLING: ARPA is handling this. They are taking steps, but they are having their problems, too. We prefer not to run to teacher.

ADMIRAL ROSE: If you were working for the Government you would have to run to teacher.

MR. FULLING: I realize that. But we are finally breaking this.

ADMIRAL ROSE: I'll tell you a story. During the war we had Lend Lease under which we gave away billions of dollars worth of material from our allies and okrselves. We had a country who wanted to buy some of

this equipment and we couldn't give them a priority because it was needed from the U. S. to be used for lend lease. There was no way to give them a priority so we couldn't sell it. We could just give it to them or we could take it for ourselves, but we couldn't give them a priority.

This was taken care of.

MR. FULLING: In this particular area we talked to ARPA last week and we were given to understand that steps were being taken to declassify this particular area. That will take about two years.

QUESTION: Sir, to what extent do private companies in the free world like Du Pont share the developments that they have in research and development areas that might have a bearing on national security?

MR. FULLING: In this particular area we don't talk to any foreign nationals about any of our research which is of interest to the Department of Defense without getting approval from the Department of Defense. Now, we have cooperated with the Tripartite Committee, and in fact the Tripartite Committee on Materials has visited Wilmington. But we have given them only the information which the Department of Defense has told us we could talk about.

QUESTION: Dr. Cavanaugh, has your explosives activity done any research in solid propellents so far as dealing with the high specific impulse? How do you compare this with the work done on liquid propellents?

DR. CAVANAUGH: We have not made those comparisons. We think there are enough people working on this so that our small contribution would not be felt. We are doing some work. About half of the government-funded research for Du Pont that Roger spoke of is in the Explosives Department,

and most of is used in connection with solid propellents. This is almost all Air Force also. It happens to be, of course, just a little job by the comparison with totals, and it is a job that we think we are peculiarly well adapted to from the chemical synthesis standpoint.

QUESTION: Most of us who have ever had plastic gloves or hoses or briefcases notice that when the weather gets cold they are very inflexible. Are you in the Company doing anything about getting more flexibility in these products?

DR. McGREW: Yes, that's a recognized problem for plastics and specifying compositions and formulations. It's a soluble problem, quite readily. The reason you have trouble is that the plastics used in these briefcases is not very expensive.

COLONEL McELWEE: Gentlemen, after that "Ask and ye shall receive, seek and ye shall find," Mr. Fulling has a short statement to make.

MR. FULLING: Gentlemen, I have one thing on which I think you in your broad area of interest should do some real thinking about. I don't want to throw harpoons at our Department of Defense or any of the leaders in our Department of Defense, but, actually, something must be done soon about utilizing American industry in the defense program, this industry which is not necessarily tied to defense contracts.

I have a word of forecast, and I will take personal responsibility for this as being my opinion, but part of it is based on fact. That is that in this country today we are rapidly developing two types of industries, the defense industry and the commercial industry. Unfortunately,

the defense industry--and I am not saying it is sour grapes, because we have the opportunity the same as anyone else--is taking on areas of research, starting and reinventing the wheel, reinventing things that the commercial industry has off its shelves. I can go on with items a yard long, and these gentlemen on my right could give you many more examples.

The thing that concerns me is that our defense program is not getting the best of the technical capability in this country because we are being hamstrung by patents, that is, the treatment of patents, and by our very difficult accounting and auditing procedures and our contractual relations. It is getting to the point where a company that is predominantly a commercial company is fast losing interest in doing defense work.

QUESTION: Mention was made of the fact that the return on investment is the base on which one determines departmental efficiency. How do you get a handle on the return on investment on basic research?

DR. JOYCE: You don't. Very naturally we keep track of the investment. This is capital investment, now, not operating money, that is in research facilities. As a matter of fact, at the Experimental Station that Roger alluded to earlier, our total investment today is very close to $100 million. The return on that is something that the manufacturing departments in their business activities have to make up.

But, if you are asking how we can measure the day-by-day or year-by-year effectiveness of a research effort in the business sense, we are no better off than anyone else in really putting a yardstick on that.

COLONEL McELWEE: Gentlemen, our panel will meet with three student committees in Room 430 at 10:30.

Gentlemen, on behalf of us all, thank you very much for a stimulating morning.