~~SECRET~~

REDACTED COPY

Congress of the United States
Joint Committee on Atomic Energy

Full Committee

Executive

Meeting No. 86-2-49 (Full)

Time: 10:00 a.m.

Place: Room F-88, the Capitol

Date: August 30, 1960

PURPOSE

To receive briefing on centrifuge process

WITNESSES

AEC

John A. McCone, Chairman
General A. R. Luedecke, General Manager
George F. Quinn, Director, Div. of Production
Charles L. Marshall, Director, Div. of Classification
Dr. Paul McDaniel, Director, Div. of Research
Dr. G. L. Rogosa, Div. of Research
Dr. George A. Kolstad, Chief, Physics and Mathematics Branch, Div. of Research

State Department

Charles Sullivan

RESTRICTED DATA
This document contains Restricted Data as defined in the Atomic Energy Act of 1954. Unauthorized disclosure subject to Administrative and Criminal Sanctions.

Department of Energy Declassification Review
1st Review Date: 6-11- [illegible] Date of Action: [Circle Number(s)]
Authority: ☐ DC ☒ DD 4. Classification Retained
Name: Roy Lee 1456 5. Classification Changed To: RD
2nd Review Date: 6/11/ [illegible] 6. Contains No DOE Classified Info
Authority: DD 7. Coordinate With:
Name: WJ Fa[illegible]456 8. Classification Cancelled
9. Classified Info Bracketed
10. Other (Specify) 74 pgs total

By Order of the Chairman

~~SECRET~~

[redacted]

EXECUTIVE SESSION

MEETING NO. 86-2-49 - TUESDAY, AUGUST 30, 1960

Joint Committee on Atomic Energy

Congress of the United States

Washington, D. C.

The Joint Committee on Atomic Energy met, pursuant to call, at 10:15 p.m., in the Committee Room, the Capitol, Honorable Clinton P. Anderson (Chairman) presiding.

Present were: Senators Clinton P. Anderson (presiding), John O. Pastore, Albert Gore, Bourke B. Hickenlooper and Wallace Bennett; Representatives Chet Holifield, Melvin Price, James E. Van Zandt, Craig Hosmer and William Bates.

Committee Consultants present: Captain Edward J. Bauser, USN, and Lt. Colonel Richard T. Lunger.

Committee staff present: James T. Ramey, Executive Director, John T. Conway, David R. Toll, Carey Brewer, George T. Murphy, Jr., and Kenneth MacAlpine.

Representatives of the Atomic Energy Commission: Honorable John A. McCone, Chairman, Honorable Robert E. Wilson and Honorable Loren Olson, Commissioners, General A. R. Luedecke, General Manager, George F. Quinn, Director, Division of Production, Charles L. Marshall, Dr. Paul McDaniel, Director, Division of Research, Dr. G. L. Rogosa, Division of Research, Dr. George A. Kolstad, Chief, Physics and Mathematics Branch, Division of Research, Myron D. Kratzer, Deputy

[redacted]

(102)

Director, Division of International Affairs, Neil D. Naiden, Acting General Counsel, Walter N. Munster, Chief, Industry Development Branch, Division of Reactor Development and Richard Donovan, Congressional Liaison.

Representatives of the Department of State: Charles Sullivan, Deputy Special Assistant to the Secretary for Disarmament and Atomic Energy and Mr. Chapin, Office of Special Assistant to the Secretary for Disarmament and Atomic Energy.

CHAIRMAN ANDERSON. The Joint Committee meets today in Executive Session to receive information on the latest developments and estimates of prospects for the centrifuge method for isotope separation.

We have with us this morning Chairman McCone of the Commission and Mr. Sullivan of the State Department, who will inform us of the latest developments in this field, both on the national and international front.

Earlier this year in Executive Session Mr. McCone informed the Committee of the improved prospects for the successful development of a centrifugal process for the separation of osotopes. The implications of success in this development relative to the Nth Nation problem, as you know, is of great interest to the Committee.

I understand that you have an opening statement, Mr. McCone. Will you please proceed?

CHAIRMAN MCCONE. Thank you, Mr. Chairman, if I may go off the record for a minute --

(Off the Record Comment)

As you have said this matter of centrifuge is of very great importance to us and to this country for the reasons you mentioned. It is also of growing importance to industry because they see in the centrifuge some potential activities. For this reason, several companies, the General Electric Company, the Dow Chemical Company and the Allied Chemical Company, have taken an active interest in isotope enrichment by a gas centrifuge method and have had extensive discussions with several of the Commissioners, most particularly Dr. Wilson. Maybe sometime this morning he will briefly review his discussions should the Committee wish to hear his views.

In the early days of atomic energy development, the centrifugal method was one of the processes considered for economical, large-scale uranium isotope separation. However, because this process was not so far advanced as alternative methods, development of the gas centrifuge was discontinued in 1944 and effort was concentrated on the processes which were employed in the wartime plants.

Information on the development efforts underway in other countries and a new analysis of the potentialities of the process led to a resumption of effort in 1953 by the United States. The Commission, under the Division of Research, has since that time supported a modest research

program with the intent of conducting basic studies on the technical and economic merits of the process and the problems of high speed rotational motion related to the improvement of the gas centrifuge unit. This classified program has benefited substantially from the presence and advice of Dr. Karl Cohen of the General Electric Company and Professor Jesse Beams of the University of Virginia who have played leading roles in the key developments in the gas centrifuge program for many years. The effort at the University of Virginia combined with the analysis made at the Walter Kidde Nuclear Laboratories has resulted in significant improvement in the outlook for the technology of the gas centrifuge method of isotope separation. Among the major achievements at the University of Virginia has been the solution, in 1957, of the problem of spinning a long tube through a series of critical vibrations, a problem inherent in high speed rotation.

During recent years, a considerable portion of the effort has been devoted to the problem of the operation of units at higher speeds. Since the separative capacity of a unit varies as the fourth power of the peripheral velocity, there is a decided advantage in higher speeds. For example, by doubling the peripheral speed, the separative capacity will be increased by a factor of 16.

Along another line of attack, the Division of Research also arranged for the conduct of a short-bowl gas centrifuge program at

the University of Virginia under Dr. Gernot Zippe,an Austrian national, who was a member of a German scientific team recruited to develop such centrifuges for the USSR. The short-bowl centrifuge method avoids the critical vibration problems encountered with long tubes. Dr. Zippe has reproduced for us this short-bowl centrifuge and has demonstrated the operation of the unit in the separation of uranium isotopes. The simplicity of this short-bowl unit, coupled with the materials improvement developed in the United States missile and other programs, indicates the feasibility of design of a short-bowl unit having considerable potential for plant-scale isotope separation.

The Commission, in recognizing the advances taking place at the University of Virginia, as well as the effort in this area underway in both West Germany and the Netherlands, arranged for a technical and economic analysis of both the long and shortbowl methods. A report analyzing the short-bowl method was completed in January 1960; the long-bowl analysis has been completed and the report is expected to be available in the near future.

The results of the short-bowl study, along with the results of some special studies undertaken at my request, indicated that the gas centrifuge process at the higher speeds now believed to be attainable and the current design simplicity offer the possibility for additional nations more easily to acquire nuclear weapons materials, within, perhaps, the next decade. In view of this potential Nth power problem, I deemed

it necessary to have the Departments of State and Defense, CIA and the Joint Chiefs of Staff briefed on the gas centrifuge method of isotope separation and the potentials of the process. Also, in view of the seriousness of the problem, I discussed the matter with the Secretaries of Defense and State as well as bringing it to the attention of the President. A report covering this subject was provided to the Joint Committee.

Meanwhile in October, 1959, I had occasion to meet with Sir William Penney, United Kingdom Atomic Energy Authority, at which time we discussed our mutual concern over the potential military significance of the centrifuge process, which can be used to produce weapons grade material as well as slightly enriched material for commercial purposes. We concluded that the present level of effort on the process in both our countries should be increased. Industrial and university groups in both West Germany and the Netherlands were pursuing studies of this process with vigor and the Germans were continuing to publish in the open literature the results of their investigations. A small-scale theoretical study is being conducted by the United Kingdom.

The Commission has taken a number of steps, about which you have already been advised, to keep technologically abreast of the potentials of the process and to minimize the possibility of additional nations' acquiring a nuclear weapons capability by means of this process. In order to accomplish these ends, we have approved an expanded three-year research and development program, estimated to cost a total of approximately

six million dollars. Provisions for this program have been made in our current financial plans and we expect to proceed shortly with this expanded effort.

Concurrently, there has been considerable interest expressed by a number of U.S. industrial companies to be permitted to develop the centrifuge process with private funds. Recognizing the sensitivity of this area of development, the Commission has studied the problem of private industrial development and has indicated agreement in principle, to permit industry to engage in the development of the gas centrifuge method of isotope separation with private funds under the access permit program and under appropriate conditions and security. Before taking final action on this matter, however, we wish to consider the views of the Departments of State and Defense. To assure meeting our own objectives, it is intended to proceed with the planned Commission program even in the area of privately financed undertakings in this area, although some adjustment in the scope or content may be required in view of the private efforts. Appropriate liaison between the private and government programs would be established and maintained.

With regard to classification, it had been our policy to conduct the gas centrifuge work as a classified program, but to declassify the resulting information after an evaluation of its significance to the national defense and security. When early in December, 1959, these reviews indicated that the U.S. efforts had made significant progress in the technology of the centrifuge, and the indication of the potential value

of the gas centrifuge as a plant-scale method of separating uranium isotopes began to appear, we concluded that strict classification should be retained. The work conducted at Virginia by Dr. Zippe, which repeated work he previously performed for the USSR, was carried out on an unclassified basis.

Cognizant of the fact that any classification action taken by the Commission could be vitiated if the German and Dutch activities were to proceed on an unclassified basis, we consulted with the Department of State on the feasibility of discussing with the German and Dutch Governments the possibility of their classifying their work and/or taking any other action necessary to control the dissemination of data, materials, and equipment. As we advised you by letter dated August 3, these discussions have now taken place with the United Kingdom, Germany and the Dutch governments. The representatives of these nations with whom our people talked have agreed with our assessment that the gas centrifuge process offers the possibility for additional nations to acquire nuclear weapons materials and have recognized the desirability of achieving uniform classification policies and practices within the four countries having gas centrifuge research and development programs. There are, however, as reported to the Committee in our letter of August 3 certain psychological - political difficulties to be overcome. All four countries will continue to be in touch through diplomatic channels in order to establish an agreed course of action with respect to classification and to explore the possibility of cooperation. Mr. Charles Sullivan

of the Department of State is here today and will be able to discuss the details of the recent visit to Europe if you wish. The Committee has been informed by our letter of August 4 of our planned cooperation with the U.K. in this area.

I have attempted to touch briefly upon our major problems and to point out that significant advances have occurred. Much detailed information has been provided to the Committee in the form of technical reports from the Commission's contractors as well as from the Commission staff and in letters to the Committee regularly reporting on our major topics.

As you no doubt recognize, Dr. George A. Kolstad of the Division of Research has been intimately associated with the gas centrifuge program; he is with us today, prepared to provide you with a further report on the technical programs in this country and abroad. Following this presentation, I shall be happy to answer any questions you may have.

I would like to reminisce just a little. As I think I told you earlier this year the group of German scientists were taken over by the Russians after the war to a laboratory to Sukhumi in the southern part of Russia -- in the Ukraine or the east of there where they worked for several years apparently on this project. The Russians were seeking a means of isotope separation for weapons purposes. Concurrently

they apparently were working on gaseous diffusion and that succeeded and they felt that was a superior process. Hence they abandoned this effort and they returned this group to Germany where they pursued their work with some of them coming over here.

We have followed it rather closely but on the premise that it would not be economically competitive with our large diffusion plants, our interest was academic. In November a year ago -- it was last November now -- Sir William Penney and I sat down in London and started to analyze this, not from the standpoint of the cost, but whether this represented a threat Nth power problem.

We came to the conclusion that there was this danger that building a series of centrifuges at a cost within the capability of almost any country, one could produce a significant quantity of weapons grade U-235 each year. These plants would be small. The centrifuges do not necessarily have to all be in one place. It would be almost impossible to detect them. This worried us very much.

This has brought about a great deal of discussion in government circles and with representatives of other governments, as my statement outlined. You will be interested to know that in talking to in France in May, they had picked up the centrifuge and were talking of using a planned gaseous diffusion plant to accomplish the lower enrichment and then a centrifuge to carry it on up higher where the amount of energy required is less.

I don't think the French have done any research but they have been in close enough touch with the Germans so that they know the potentiality of the centrifuge.

Mr. Sullivan will report on his trip and Dr. Kolstad on other aspects of this.

I look upon this as one of the very serious problems. A modest size plant would produce more weapons grade material than a series of the very large power reactors for which we are having difficulty providing proper safeguards under the International Agency.

CHAIRMAN ANDERSON. Is there any possibility the Russians do not have any ideas along this same line?

CHAIRMAN MCCONE. I can't answer that,of course. We don't know.

CHAIRMAN ANDERSON. Zippe was in Virginia for quite a while. He has now gone back to Germany. Is he available to the Russians or is he not?

CHAIRMAN MCCONE. I don't think so. I think one of two things happened. Either the Russians saw that this did not serve their purpose so they dropped it or they had extracted all they thought they could extract from the Germans and thereby dismissed them and then carried it on themselves. Of the two, I would think the latter is more likely because I haven't seen the Russians inclined to drop much of anything that had potentials of this kind.

REPRESENTATIVE PRICE. Since the Russians have other sources, you wouldn't be so much concerned whether or not they did have this program. Your concern is the smaller nations getting into this area?

CHAIRMAN MCCONE. Sure. The only thing that concerns me with the Russians is that it might serve as a clandestine method of their continuing production under some disarmament program in which their larger plants would be padlocked.

REPRESENTATIVE PRICE. With these smaller facilities they could hide them, but with a gaseous diffusion plant -

CHAIRMAN MCCONE. They could hide them almost any place.

REPRESENTATIVE HOSMER. Whom are we afraid of as the Nth power in this thing?

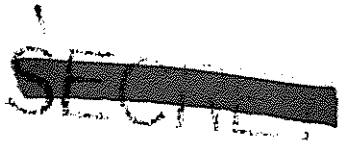
COMMISSIONER WILSON. Cuba.

CHAIRMAN MCCONE. You could answer that yourself, Mr. Hosmer. Japan, Israel, Egypt, Argentina.

REPRESENTATIVE HOSMER. Generally those countries which have some industrial base.

CHAIRMAN MCCONE. Countries of some industrial base. You wouldn't worry about the primitive countries, but you would worry about some industrial country. This might very easily fall within the capacity of a group of Chicago gangsters, you know.

REPRESENTATIVE BATES. What do you expect it to cost compared with the present system?



CHAIRMAN MCCONE. There is a report, of which I am sure you have copies which indicates -

REPRESENTATIVE PRICE. Mr. Chairman, my attention has been called to something. I was distracted when you said something about Chicago gangsters. Can't you pick some other town.

(Laughter)

REPRESENTATIVE BATES. Not as good an example, I don't think.

CHAIRMAN MCCONE. I will throw in Hollywood. There was no personal affront meant, Mr. Price.

When a speed is increased from the present level of 300 centimeters per second to 450 meters, which seems to be attainable, a plant costing $8 million, employing 160 people could be constructed and operated in less than four years and could produce a substantial quantity of weapons grade material. We think that if an advanced nation such as Germany, for instance, undertook this, they could produce their first weapon in less than five years.

REPRESENTATIVE BATES. And cost-wise, any projections?

CHAIRMAN MCCONE. Dr. Kolstad will cover this in detail.

REPRESENTATIVE BATES. You are going to have a description of the process.

CHAIRMAN MCCONE. Perhaps it would be well for Dr. Kolstad to go forward.

DR. KOLSTAD. The interest of the Research Division harks back to about 1951 when the Director of Research at that time appointed a special "High Hope" Committee, chairmaned by Professor Harold Urey, to look into various methods of isotope separation and make recommendations as to what other areas the Commission might be exploring that weren't at that time being adequately covered.

One of the recommendations which they made was that we ought to take a look at the gas centrifuge because at the time the gaseous diffusion was chosen back in 1941-1942, it seemed that the two were economically roughly competitive, but the diffusion process was further advanced and a decision had to be made so the gas centrifuge was dropped.

In 1953 we initiated some economic and technical analyses and theoretical work of the centrifuge process at the Walter Kidde Nuclear Laboratories under Dr. Carl Cohen and a few months later started an experimental effort at the University of Virginia under Dr. Robert with the advice of Professor Beams. Professor Beams has been the constant advisor on that work at the University of Virginia.

I might say that the investment so far in research and development work by the Research Division is about $1.5 million since 1953.

Let's take a look at what a centrifuge looks like. It consists essentially of a spinning tube inside a steel case. The case itself is evacuated although there are even arguments for putting in hydrogen

gas here to effect heat transfer between the two walls.

DOE 6.2(a)

DELETED

The idea here is that the product or the feed comes in through the pipe, which stops at the middle here -- this red pipe-- and the gas circulates around inside the centrifuge. Of course it is on both sides. We just dotted it on one side. So there is a net flow of gas downward along the axis and upward along the peripheral. The centrifical forces, of course, are sideways. They are very strong -- millions of times greater than gravity.

SENATOR HICKENLOOPER. What gives the force to that gas so it will take that pattern?

DR. KOLSTAD. Just the fact the whole system is spinning. There is a certain amount of friction against the wall.

SENATOR HICKENLOOPER. Comes down and then comes up on the outside.

DR. KOLSTAD. There also can be temperature differences between the top and bottom to encourage this kind of circulation. The net effect of this centrifical force is to cause a diffusion to the outside wall of the heavy atoms -- U-238 -- relative to the light ones so at the top one ends up with which is rich relative to the U-235 than one has at the bottom. One puts in scoops at the top and bottom and takes out

the top product which is richer in U-238 and takes out the bottom product which is richer in U-235.

One thing that should be borne in mind with this process is a rather fundamental difference between the gas centrifuge and gaseous diffusion. The separating efficiencies of the gas centrifuge depend on the mass difference of the isotopes which one is separating. For example, in the case of U238 and U-235 the mass difference would be three. The first is eight. The gaseous diffusion process and any diffusion process depend on the square root to mass ratio of the two products one is trying to separate.

What this means is that the gas centrifuge is in a unique position with respect to unit mass separations at the end of the periodic table where the mass difference is large, but the square root to mass ratio is very low. This means, for example, if U 238 needs to be separated from U-235, the gas centrifuge is three times better than would be the case of U-238 from U 235 where the same two systems -- for two plants of the same type operating on gaseous diffusion or gas centrifuges.

This fundamental property means that for separations other than the normal U-238-U-238 separations, such as the U-236 from U-235 or plutonium 240 from plutonium 239, the gas centrifuge has a unique advantage. Another advantage is the handling of radioactive bases or unstable gases which form deposits which might plug up the fine pores. This was the case with plutonium where it is difficult to make a stable plutonium

hexafluoride without decomposition. Further work on that has indicated that one can now maintain plutonium in the hexafluoride form.

Incidentally feel free to interrupt with any questions along here. I will just pass on to the next one.

REPRESENTATIVE HOSMER. Before you do, in the case of the heavier isotopes --

DR. KOLSTAD. Yes.

REPRESENTATIVE HOSMER. I can understand why they will proceed outward to the sides, but why would they be removed at the top and the lighter ones removed at the bottom?

DR. KOLSTAD. There is a stationary scoop here -- fixed with respect to the whole system which is rotating. Gas comes in here at high speed and just forces out through the scoop -- it is a tube with a little hole in the end -

COMMISSIONER WILSON. He means, Why?

REPRESENTATIVE HOSMER. Then you take out the lighter gas- -

DR. KOLSTAD. In this same fashion at the bottom.

REPRESENTATIVE HOSMER. Why should at the bottom there be a collection of the lighter isotopes rather than some place else?

DR. KOLSTAD. The reason is that you have the stream going down the axis and a stream going up the periphery. The high speed rotation gives a force horizontally so that there is a net migration of the U-238 to the outside relative to the U-235 so that as one goes up the U-238

content relative to the U 235 becomes greater. At the top you have a higher enrichment in the heavy isotope.

Incidentally this whole thing can be reversed so that one picks off the heavy isotope at the bottom and the lighter isotope at the top just by changing direction of gas flow.

REPRESENTATIVE HOSMER. Is the gas maintained in there for a long period of time or is it accomplished within a short period of time? It is a continuous process of some kind, but -

DR. KOLSTAD. This, of course, depends upon the operating characteristics of the unit. The higher the speed of the units, the faster it will carry out its separation.

REPRESENTATIVE HOSMER. Is it a matter of seconds or days?

DR. KOLSTAD. It is a matter of hours.

COMMISSIONER WILSON. Continuous fundamentally.

REPRESENTATIVE HOSMER. If the flow is down, you are not putting much gas in -

DR. KOLSTAD. The throughput, of course, is one of the basic factors one has to consider -- the throughput and separation. It is a product of the two that determine how effective the system is.

REPRESENTATIVE HOSMER. Is this done in stages?

DR. KOLSTAD. Yes. One needs several thousand of them to make a plant. This is an indication of a 10,000 unit centrifuge cascade.

With such a cascade one has the feed coming in at the center and one has along the axis, say, 1732 centrifuges on this axis. This one has six stages in the cascade. In the second stage of the cascade there will be 1300 and in the third stage 946 and so on up to 172 at the top. Similarly in the other direction the wastes will come out at the bottom end and the product at the top end.

This cascade was drawn up for the production of 75,000 kilograms per year of 2 percent uranium 235 and is equivalent to -- the same number of centrifuges could be used to produce 500 kilograms of weapons grade U-235. The only change that one would have to make -- and this is one of the important points from the point of view of interest in the power problem -- is in the plumbing. One would then make the cascade narrower and longer. This would result in a higher enrichment, but a smaller throughput.

REPRESENTATIVE HOSMER. That is one unit and the cascades are divisions within?

DR. KOLSTAD. The centrifuges are within the cascade system. This is a cascade of ten thousand units.

REPRESENTATIVE HOSMER. You have ten thousand separate centrifuges?

COMMISSIONER WILSON. You don't need anything like that number in the 150 per second peripherical speed.

CHAIRMAN MCCONE. What is the size of each one of those units?

DR. KOLSTAD. Each one of the units is about 50 centimeters long and 20 centimeters wide -- between 50 and 60. Size is rather arbitrary. One has these of all different sizes. For this particular cascade that was about the size that was chosen.

The point is that the only thing that is needed to change the broad cascade for producing commercially useful 2 percent U-235 to a weapons plant is merely a change in plumbing. It would be the same units. If one designed the plant properly, we would just have to change the valving.

A study which was undertaken by the General Electric Company last year indicated that following a three year development program it would be possible to build a plant, about the size of 10,000 units indicated in the previous cascade, which would produce U-235 at a price which would be competitive with the AEC price list. This doesn't mean it would be competitive with our actual cost against diffusion, but it would be close enough to be of considerable interest.

This is the kind of experimental program that has been envisaged; namely the improvement of the super critical components, the long tubes Mr. McCone referred to as being carried out at the University of Virginia, advanced mechanical studies, study of hydrodynamic flow within these tubes which presumably is probably the most important part of the whole thing to get the efficiency of the units up to what has been experienced with the German units and with earlier experiments during the war.

Then there are cascade experiments and cascade studies and improvement of the current subcritical unit which Dr. Zippe developed at the University of Virginia to get their separating efficiency up to the necessary amount.

DELETED

DOE 6.2(a)

but the Zippe units have not demonstrated that kind of operating efficiency.

There has been a slight change in number of units from the 10,000 that was in the previous cascade to 13,000 in here. The reason is because it was recognized that the efficiency, which was assumed for the 10,000 unit was probably a little high to be immediately attainable. So with 13,000 units one has these kind of costs per centrifuge. It has been normalized to number of centrifuges. $100 per installation cost, $89 for start-up and 4 months of operation, $410 for building and the land, which is about 3 acres, $1110 for each centrifuge for a total of $1718 plant investment for a plant -- that is per centrifuge -- having 13,000 centrifuges in it, occupying an area of 150,000 square feet and producing 75,000 kilograms per year of 2 percent material or 500 kilograms per year of weapons grade material. (Total Plant). These are cost uncertainties which were factored into the detailed cost analysis. Plus 800 and minus 300, indicating spread -- to go up by 800 or down by 300.

This means it lies between $14 million and $25 million for the cost of such a plant. Plant size is 148,000 feet. Plant power is 1.3 megawatts. Our experience has been that it will actually come closer to the higher number.

MR. RAMEY. In making calculations on operating cost, were you assuming private financing or government financing?

DR. KOLSTAD. The cost analysis was made by the General Electric people under contract to the AEC, but using their internal costing practices--private practices. I don't know of any major point of discrepancy between their method of accounting and ours. I am not an expert on that.

MR. RAMEY. The interest factor would be less.

DR. KOLSTAD. Yes.

CHAIRMAN MCCONE. It is interesting to note that on the basis of those figures, 500 kilograms would cost between $14 million and $25 million; 3,000 kilograms would cost about a maximum of $150 million. The French gaseous diffusion plant which is estimated to produce 3,000 kilograms is estimated to cost $750 million. And the French gaseous diffusion plant is supposed to have 600 megawatts of power, isn't it?

DR. KOLSTAD. I don't know.

CHAIRMAN MCCONE. I think it is. This takes 1.3.

DR. KOLSTAD. This curve shows how the relative economy of the centrifuge process has changed over the years-- and not very many years at that. This is the ZG 3 unit which doesn't mean anything to most of you. It is the German centrifuge which was developed after the war three of which have been sold to the Brazilians and was the basis for the earlier cost estimate made by our people at Carbide and Carbon. It is the unit which operates at 300 meters per second peripheral speed and it is about a meter long and about 15 inches in diameter.

The cost here along the vertical axis -- we have a cost in dollars per kilogram of uranium separated work. This should be the AEC price list which is around $30.00.

Then the first improvement over that German unit has been the unit developed by the Russian Group at Sukhumi on the Black Sea which has been reproduced by Dr. Zippe at the University of Virginia. Factored in here is that unit at its present operating efficiency--

DOE 6.2(a)

DELETED If one can get this to operate at the kind of efficiencies we have experienced in other units, it brings it up to here which is getting in this region. The upper curve represents the upper limit of the estimate of cost of the plant and the lower curve of the lower level. This is the spread in estimating. The reason for the break here is that beyond this break we don't have the units. These are based on actual units in hand. These are based on units which people say they can make.

MR. RAMEY. You mentioned the AEC price level. What is that?

DR. KOLSTAD. About $39.00 per kilogram uranium separated work.

COMMISSIONER WILSON. That is quite different from the price list on the product. That would correspond, however, to that same price of the product at a slightly higher raw material cost than we now have.

DR. KOLSTAD. The Germans have since developed their so-called ZG-7, which is a faster unit and operates at about 360 meters per second and is larger. It is longer. It is about the same diameter but longer than the SP unit. This falls in here. The units which were contained in the GE report, which we believe are attainable -- in other words these are based on in hand technology which has come about largely as a result of the missiles program where we have been able to get very high strength materials -- fall in here.

This is the 450 meter per second centrifuge of the size indicated for the previous cascade. This bracket -- at AEC price list. If one long bowls factors in the/development that is going on at the University of Virginia, which would require a longer development time and is a somewhat more costly development program, one would expect to end up with a cost somewhere in this region.

I should point out that although the speeds indicated in the GE report are about 450 meters per second, the group at the University of

[redacted]

Virginia

DOE 6.2(a)

DELETED

REPRESENTATIVE HOSMER. The difference between the short bowl and the long bowl then has been a long axis of centrifuge -

DR. KOLSTAD. That is right. Separating power is directly proportioned to the length of the tube and, as Mr. McCone mentioned, it is also proportioned to the fourth power of the peripheral speed. This is a very important factor and one of the reasons why we are trying to get higher speed rotation. It isn't completely simple though because as you go to higher speed rotations, you run into process problems because of the tremendous differential temperature between axis and periphery, so very high speeds will begin to run into liquid fashion.

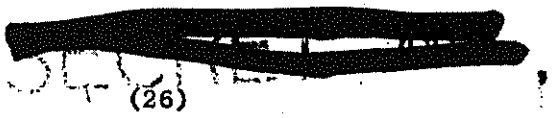
REPRESENTATIVE HOSMER. The difference between the short bowl and the long bowl is dictated by the availability of materials that will withstand the low bowl strains.

DR. KOLSTAD. The material problem is essentially the same for the two, but the difference between the long bowl -- you have the same thing as you have in vibrating string.

DOE 6.2(a)

DELETED

[redacted]



DOE 6.2(a)

DELETED

REPRESENTATIVE HOSMER. The only difference in a short bowl is that you run your gas through slower. Is that the only difference?

DR. KOLSTAD. The flow of gas through would be the same of course. It would stay in the long bowl longer because there is a longer path for the gas to follow. Per unit length of tube for a given rotating speed, the gas sustains for the same length of time.

COMMISSIONER WILSON. You need many less of the long bowls for a given amount of separating work than you would for the short bowls.

DR. KOLSTAD. Less units. In other words, if the long bowls were three times longer than the short bowls, one third as many units, one third drive motors, less plumbing and it would cut the cost.

There is a cost analysis made by the industry -- by the Union Carbide people, the K-25 group, which shows the comparison between various types of gas centrifuges with the actual costs of gaseous diffusion.

The current 300 meter per second German unit or the current one years ago is shown up here. This dotted red line shows the gaseous diffusion costs. This is cost as a function of plant capacity.

As you know the real advantage for a centrifuge compared with gaseous diffusion is for small plants. You just can't build a small plant with a gaseous diffusion process while you can with a gas centrifuge.

The improved Zippe unit which I showed on the previous graph costs the same as a diffusion plant with a capacity of about 400 kilograms uranium separated work per day. Future improved unit, which the K 25 people, envisage as just barely being possible is 500 meters per second bowl and this one shows that the cost falls below gaseous diffusion all the way out.

COMMISSIONER WILSON. Do those two lower curves assume

DELETED

DOE (6.2(a))

DR. KOLSTAD.

MR. RAMEY. Are you using that $39.00?

DR. KOLSTAD. No, this is the actual cost of gaseous diffusion by present technology.

SENATOR BENNETT. Regardless.

MR. RAMEY. When you are talking about price schedule being at $17.00 a kilogram -

DR. KOLSTAD. I am not able to report here what number one should use for that. Perhaps someone from the Production Division -

CHAIRMAN MCCONE. Perhaps Mr. Quinn could answer that.

MR. QUINN. The lnne labeled gaseous diffusion throughout at the large sized plants should come out to about the $39.00 figure. This is the cost of the actual separative work in the plant as distinguished from the cost of the product. It is consistent with the $17.00 gram top product in the price scale.

COMMISSIONER WILSON. That assumes a higher raw materials cost than the present though.

MR. QUINN. Right, but raw material does not enter into this curve at all. It is what the plant can do and what the operating costs are.

DOE 6.2(a)

DR. KOLSTAD. DELETED

This is the G-3, the earlier German unit or three year old technology. The analysis made by the Carbide people showed that the plant producing 500 kilograms per year of weapons grade material would cost about $100 million. Scaling this down by a factor of ten, we estimate the cost scaled down by a factor of approximately $37 million. This would be for a plant which would produce either 7,000 kilograms per year of two percent or 500 kilograms per year of 95 percent material.

SENATOR HICKENLOOPER. I don't understand those two top figures. It says 500 kilograms a year - $100 million; 50 kilograms a year is $37 million. What is the significance of that?

DR. KOLSTAD. The size doesn't scale linearly with production schedule. It scales down by square root. Conversely if you go to a higher capacity, the cost doesn't go up. Conversely if you go to a larger capacity, the cost does not go up linearly just as they do not go down linearly.

CHAIRMAN ANDERSON. Would you say it in less scientific terms by saying that as you increase you get greater efficiency out of the plant and cost goes down.

DR. KOLSTAD. That is a better way of putting it, I think.

REPRESENTATIVE HOSMER. Mass production economy.

DR. KOLSTAD. There are a number of companies which have expressed an interest to us in one way or another in the gas centrifuge process: General Electric, Westinghouse, Allis-Chalmers, Sharp's, DeLaval, Sperry, Thor-Westcliffe, Spencer Chemical, Dow Chemical, Carbide and Carbon, Decker Corporation, Allied Chemical and a group of mining interests.

CHAIRMAN ANDERSON. Can you tell us why that would be secret if all of those firms are working on it? If all of those people know about it, what is the use of keeping it secret?

REPRESENTATIVE HOSMER. I want to know what they are interested in. Are they interested in getting the contract for the Commission or using it in their own plants on some other isotope?

DR. KOLSTAD. Of course everybody doesn't feel the same. There are some industries which are strongly interested in putting in their own money to develop this. There are others which feel this is going to be a government monopoly for a long time and they feel the development should be done by the government.

REPRESENTATIVE HOSMER. Is their interest in achieving a means of separating uranium or plutonium or something lighter on the scale that they can use in their civilian business or what?

DR. KOLSTAD. All Sperry are interested in is in spinning stuff. So you can count them out. I should point out that this process is probably not useful for atomic numbers less than 40 -- down around the middle of the table. Down about 40 chemical methods are probably cheaper, but the heavier end of the periodic table is the one that has considerable interest. The companies which have talked to us have not expressed interest in anything other than U-235.

REPRESENTATIVE HOSMER. In other words they want a job from the Government.

COMMISSIONER WILSON. Some of them do.

DR. KOLSTAD. Mr. Munster could probably speak to that better than I could.

REPRESENTATIVE PRICE. Mr. McCone, in your statement you said one of your concerns was to minimize the possibility of additional nations getting into this area. Won't this increase the possibility of

additional nations getting into it?

CHAIRMAN MCCONE. As I said in my statement, to keep this under classification hopefully by arrangement with The Netherlands, Germany and the United Kingdom and to the extent that manufacturers work on it. They work in one of two ways: either on a classified project using their own funds through the medium of an access permit or direct contract with us.

REPRESENTATIVE PRICE. The wider you open up a program even here at home, the greater the possibility that it will spread among other nations.

CHAIRMAN MCCONE. That is correct.

CHAIRMAN ANDERSON. Let me get back to this secret again.

On that paper that says, "Interested U.S. Industry" -- and just gives a group of names that are identified with the centrifuge. Yet it is "Secret".

DR. KOLSTAD. That is strictly an error. All the charts when they are made up are just labeled "Secret" --

CHAIRMAN ANDERSON. Just classified Secret as a matter of habit.

MR. MARSHALL. I think that was just the chartmaker who did that. Nobody in official position -

CHAIRMAN ANDERSON. But it will become Secret from there on out and they will defend it to their dying day.

COMMISSIONER WILSON. With respect to Senator Anderson's question as to how it happens so many people are interested in -- fairly interested, of course the German manufacturers of this had a lot of publicity and a lot of salesmen around so everybody who made centrifuges or used them wanted to get into the act. Some of those aren't really seriously interested. There are only three or four who are seriously interested in going ahead and spending a substantial amount of their own money in development.

CHAIRMAN ANDERSON. I am more interested in how a thing gets classified and you can never get it unclassified. We had a matter up here which, so far as I know, is still classified in the Joint Committee yet it has been published in newspapers all over the country.

REPRESENTATIVE VAN ZANDT. I wonder if I might ask the Commissioner whether the Germans have sold any to date. The last time we discussed this matter, I understood they had sold or were in the process of selling -

DR. KOLSTAD. Three to Brazil.

SENATOR BENNETT. These are single centrifuges.

DR. KOLSTAD. Yes.

REPRESENTATIVE HOSMER. Are they getting any U-235?

REPRESENTATIVE VAN ZANDT. Just a minute.

CHAIRMAN MCCONE. Haven't they sold 7 to Thor-Westcliff?

DR. KOLSTAD. They haven't been delivered.

CHAIRMAN MCCONE. They have sold them.

DR. KOLSTAD. They have taken the order.

CHAIRMAN MCCONE. They have taken an order of 7 for Thor-Westcliff a U.S. firm, as I remember.

REPRESENTATIVE VAN ZANDT. Then that is 7 to a U.S. firm and 3 to Brazil.

CHAIRMAN MCCONE. We have no further information on it.

DR. KOLSTAD. One other point is the Brazilian units are three old type German units. The ones ordered by Thor-Westcliff are the more advanced.

REPRESENTATIVE VAN ZANDT. I was wondering if Castro might buy a few of them.

REPRESENTATIVE HOSMER. What is Thor-Westcliff going to do with it?

DR. KOLSTAD. When Thor Westcliff applied for an import license we granted it on the grounds it wanted to set up a cascade of these units and carry out research and development work on them. They have, I believe, an application for a production facility license which has not been issued. The units have not been delivered.

REPRESENTATIVE HOSMER. They want to run uranium hexafluoride through them. There is no commercial application for this process.

DR. KOLSTAD. Other than isotope separation.

REPRESENTATIVE HOSMER. Uranium isotope separation.

DR. KOLSTAD. It is useful for separating any isotope of atomic weight greater than about 40 that you can make a gas out of; a gas that

will be stable at that temperature.

The present situation is that the study that the General Electric people have made -- and we have gone over it with them and agree-- indicates feasibility of plant construction by 1965, the one with the launch right ahead.

The University of Virginia development -- these long tube developments would cut these costs both for operation of the plant and for construction of the plant, but would increase the cost and complexity of the developmental effort.

Thirdly the materials now available both here and abroad will permit peripheral speeds of 400 meters per second or greater. Compared to the World War II units, this is a factor of about ten. The separating efficiency varies at the fourth power.

On the foreign work, the Soviet Union and satellites, I will describe in a little more detail on the next chart. West Germany, Netherlands, the United Kingdom, Brazil and the Canadians have recently put a chemical engineer on to the work. The Japanes have launched a small research and development effort in the University of Tokyo.

The work in the Soviet Union, which was mentioned earlier, was carried out at Sukhumi. This was under Professor Steinbeck. There were two people with him, with whom we have been in contact. One is Zippe and the other is Schaefel. Zippe was brought back to the University of Virginia to reproduce the Russian work. Schaefel was picked

up by Degussa at Frankfurt and has been reproducing it there in a somewhat larger unit. Steinbeck is in East Germany and is head of an Isotope Separation Project pursuing the gas centrifuge method. There have also been publications coming out of Poland on this process and we understand from Dr. , Director of Research at Degussa and from independent confirming reports by visiting Soviets and Poles that the Russians when they learned of the increased interest in this process by Degussa or in West Germany reactivated their work in this field.

CHAIRMAN ANDERSON. That goes back to the same question of classification. If the East Germans are actually trying to sell these plants -- actively trying to sell them, what hope is there to keep this sort of thing Secret since the Russians know about it and worked on it in their own plants? If Poland knows about it and the Russians know about it, how secret is it?

CHAIRMAN MCCONE. It is a question of whether or not it is possible to sweep it under the rug. This is a hard question to answer. The work of the Dutch has been kept Secret. They have kept it under a type of industrial secrecy. The work in Germany has not been widely broadcast.

CHAIRMAN ANDERSON. If they are out selling them, why isn't it broadcast? You just don't make an automobile and try to sell to people and then say, "This is a secret device."

COMMISSIONER WILSON. If the West Germans classify it, that would take care of the German situation.

CHAIRMAN ANDERSON. It might keep it classified in the future, but if they are out selling now and suddenly classify it, doesn't that tell the Russians you have increased interest in it?

COMMISSIONER WILSON. Undoubtedly it does. It isn't the Russians we are worried about. It is the Nth power. The Russians won't profit very much by it anyhow.

CHAIRMAN ANDERSON. When you say "Nth" power, do you mean France?

COMMISSIONER WILSON. I am personally concerned more with the still smaller nations that might just use it to blackmail.

CHAIRMAN ANDERSON. I am trying to find out who?

COMMISSIONER WILSON. Israel, Cuba -- anyone of a number of small nations that want to be more or less obstreperous and they might, just as France did, make this stupendous effort at much greater cost in order to be a member of the Club.

REPRESENTATIVE PRICE. If Germany sold them to Brazil and to an independent corporation of the United States, wouldn't they sell these other countries too?

COMMISSIONER WILSON. If they classify it, then they won't. That is why Mr. McCone feels that classification by Germany and the Netherlands is a necessity if we are going to keep it secret.

REPRESENTATIVE PRICE. As of now you haven't reached that sort of an agreement.

COMMISSIONER WILSON. We are well on the way.

REPRESENTATIVE PRICE. This is what you hope to do.

CHAIRMAN MCCONE. Mr. Chairman: - Mr. Sullivan is here. He headed up a group that went over to talk to the Germans and the Dutch. He might throw some light on this.

MR. SULLIVAN. If I could just make one comment on this point sir. I think it is probably generally known that Degussa, for example, in West Germany is working on the process. I don't know how generally known it is that ~~all of the~~ other plants in Germany are working on the process are interested in it nor the Netherlands. This being the case, I think it is advisable not to leave it in unclassified form so it can be broadcast.

CHAIRMAN ANDERSON. Do you happen to know whether or not the Germans have applied for patents in a great many countries?

MR. SULLIVAN. I don't know the answer to that question, sir.

CHAIRMAN ANDERSON. Wouldn't that be a good question to know the answer to?

MR. SULLIVAN. Yes.

CHAIRMAN ANDERSON. Of course they have. How come the State Department couldn't find out?

COMMISSIONER WILSON. They have applied -

CHAIRMAN ANDERSON. The Committee knows. Mr. Wilson knows. Why doesn't the State Department know?

MR. SULLIVAN. We learned in our discussion in Bonn, Senator, that there are 17 patents at the moment -- I believe that was the number that they gave us -- that the Germans have registered with EURATOM, for example, and those patents are in the hands of the German scientists and I think Degussa is the other. I don't know whether there are any other German firms that are interested in applying for patents.

I think, sir, the explanation for this classification would be at this point we just don't know how widespread the knowledge of these things is at the moment and there is a question of whether it is desirable just to leave it wide open at this point. I believe -

CHAIRMAN ANDERSON. I am just trying to find out the basis for it if the Germans are out selling; if the Germans have applied for patents in 17 countries or whatever the number of countries it may be.

What about the countries that Mr. Wilson is worred about? Can't they go over to Cuba and apply? Can't they go to Israel and apply for a patent there and offer to sell as they have sold to Brazil?

How do you take it out of the market? What are you going to pay them for staying out of the market? What is your proposal in order to get them to classify? Are you offering to pay them so much money so they won't use it?

MR. SULLIVAN. This is one of the points I planned to cover, sir, when I mentioned the discussion with the Germans and Dutch because this is a problem that we have to deal with.

I don't know at this moment in how many countries the Germans have applied for patents. We know they have applied for 17 in EURATOM. In other words they have notified EURATOM of 17 patents that are pending by either scientists or German industry.

CHAIRMAN ANDERSON. That is six countries so Dr. Wilson won't be worried about France, West Germany, Belgium or the Netherlands -

COMMISSIONER WILSON. Wait a minute. I don't say that a person could take an assortment of patents and really go out and build something like this. You have got 17 patents. I would rather there were 17 patents than one because if people have to try out 17 different things, they may not find the right one first.

CHAIRMAN ANDERSON. They don't have to find it out. They can buy it.

COMMISSIONER WILSON. The fact a patent has been applied for doesn't necessarily give out secrets. Know how in this consideration is very important.

CHAIRMAN ANDERSON. You don't think they can go to Germany and buy one today.

COMMISSIONER WILSON. If we are able to get Germany to agree to classify, they won't be able to.

REPRESENTATIVE HOSMER. Wait a minute! These developments in Germany are being carried on by private firms.

COMMISSIONER WILSON. That is right.

REPRESENTATIVE HOSMER. They are putting in their own money. They expect to get their money out.

COMMISSIONER WILSON. If Germany classifies, they can't any more than one of our firms can.

REPRESENTATIVE HOSMER. It is going to take governmental action to clamp down on the whole thing.

COMMISSIONER WILSON. Absolutely.

REPRESENTATIVE HOSMER. To whom have you been talking -- the Government or companies?

MR. SULLIVAN. We talked with representatives of several German government agencies. We did not talk with either Degussa or other firms.

REPRESENTATIVE HOSMER. Degussa is going to fight like mad to get its investment out of it.

MR. SULLIVAN. What is necessary is first for the German government to impose classification. Once that is done, it is up to them to control it on the same basis that we would control it here in the United States

if U.S. firms were engaged in work on a classified basis. This would involve German classification which would be imposed not only on the work of the firms, but the work of the scientists as well. The latter at this moment is probably more important.

COMMISSIONER WILSON. It should be emphasized that this very high speed work at the University of Virginia has not been equaled by anyone else so far as we know.

CHAIRMAN ANDERSON. The man who did that has gone back to Germany.

COMMISSIONER WILSON. No.

CHAIRMAN ANDERSON. He has not?

COMMISSIONER WILSON. He didn't have access to classified work over here. He worked at the University of Virginia on an unclassified laboratory development.

CHAIRMAN ANDERSON. I am talking about Dr. Zippe.

COMMISSIONER WILSON. I mean Zippe. Zippe worked only on unclassified matters in the development of the short bowl.

CHAIRMAN ANDERSON. He doesn't know anything about this other?

COMMISSIONER WILSON. We tried our best to make sure that he didn't. If classification works, he doesn't.

GENERAL LUEDECKE. He didn't have access.

CHAIRMAN MCCONE. I think the answer to this, Mr. Chairman, is that it is a serious problem. It is recognized as an important problem [redacted]

by both Germany and the Netherlands. As to any clear pattern of how we are going to control it, we haven't reached that point yet. It may have gone entirely past the point of no return. Maybe we can't do anything about it at all.

SENATOR PASTORE. May I ask a question of Mr. Sullivan? Have the Dutch recognized Red China?

MR. SULLIVAN. ~~No, they have not.~~

SENATOR PASTORE. That is what I am worrying about. Unless this thing is classified pretty quickly, it can easily get to the Red Chinese. Then we are in serious trouble. Let alone to Israel or Cuba, if it ever gets to the Red Chinese, we are in serious trouble.

DR. KOLSTAD. Getting on with the technological capabilities required to pursue this: a source of uranium, high speed drive motors, pumps, high speed bearings, rotors with the tubes and primarily mechanical engineering manpower. The problem is probably equivalent to building and operating a plant employing about a thousand people to manufacture washing machines, refrigerators, automobiles and the like. There is a slightly higher advanced technology involved, but the problems are not otherwise of serious moment.

SENATOR GORE. When you make that comparison, are you saying that it is within the industrial capacity of many nations?

DR. KOLSTAD. That is right.

COMMISSIONER WILSON. If you told them a few things.

DR. KOLSTAD. Taking a sort of an arbitrary breakdown of the capability of nations, nation X being a nation such as the United States or Germany or Sweden with a high industrial capability; Y being an intermediate country like, perhaps Israel, with some good technical competence but not a broad base that some of these other countries have and nation Z, the substantially underdeveloped country which would have to import its talent to do the job. I would think perhaps Cuba would be a nation Z.

We have taken then two types of unit: the unit which is on the shelf and available at any time, the 300 meters person unit, and a 45 meter per second unit which we believe is in hand technology but requires a development program. In this country the development program would take about three years. Elsewhere it might take longer.

The costs are shown here for different types of units -- the centrifuge cost, feed materials and the fabrication of metals to weapons showing that for a class X country, based on a 300 per meter second unit the cost would be about $43.5 million; based upon the advanced unit $8.5 million. These are costs to produce one bomb a year or 50 kilograms a year. For a class Y country, such as Israel, the cost becomes somewhat higher for both sides of the picture and for a class Z country the costs are still higher -- $51.8 and $10.2.

The time required is, of course, less for the most advanced countries -- 3 years for a country like the United States to 7.2 years for an underdeveloped country.

COMMISSIONER WILSON. You are showing the same construction time for the 300 meter and 450 in the Y or Z class. It is certainly going to take quite a bit more development work really, assuming you gave them all the technology.

DR. KOLSTAD. Yes, that -

CHAIRMAN MCCONE. That is after the development work is done.

COMMISSIONER WILSON. I see.

DR. KOLSTAD. The operating costs similarly go up to $6.3 million for the advanced country and $2.3 on the advanced unit and $6.9 and $2.9 in the Class Z countries. This is an indication of manpower requirements. Again they go up in the less developed country. The time required to produce the first weapon is shown at 3 to 5 years for a Class X country and about 8 years for an underdeveloped country. This assumes of course that people are available to be brought in to do this job.

In summary, we are in the position that we believe given a three year development program costing about $6 million, we could build a plant costing between $4 million and $5 million which would produce 500 kilograms per year of weapons grade material and an operating cost of about $3 million. Power consumption is between 1 and 3 megawatts and covering an area of about 3 acres.

Finally -- and this is just a consideration that we are faced with -- what to do about the expanded U.S. research and development effort? What do we do about collaboration with the United Kingdom, West Germany and the Netherlands? What do we do about classification? What do we do about safeguards -- information control and materials control?

CHAIRMAN ANDERSON. Mr. Sullivan, do you have a statement?

MR. SULLIVAN. Mr. Chairman, I do not have a prepared statement, but I would like to give you a brief outline of the discussions that took place in Germany and in The Hague. The United States' team consisted of representatives of the State Department and the Atomic Energy Commission. We met in Bonn on July 13 and 14 with representatives of the German Atomic Energy Ministry, their Department of Justice, the Foreign Office and other interested agencies.

As Chairman McCone indicated, the Germans did agree with our assessment of the potential of the centrifuge as a source of weapons grade material. They agreed -- and quite readily agreed that some action should be taken to control the process. The control would involve one or several actions: control over information and control over material and control over the process or technology of the process.

As for the immediate future the important thing is obviously classification of information because you can see from the briefing of Dr. Kolstad, it is going to be several years before the more sophisticated

centrifuges are going to be available for sale.

We took the approach with the Germans of primarily pointing out at this time why we felt it was necessary to classify. They reacted by volunteering that it was desirable to classify and that they would undertake an immediate study to see what would be required. We would expect to hear from them soon as well as from the Dutch. In addition, I might mention at this point that we expect also that prior to hearing from the Germans and the Dutch that there will be a discussion between representatives of the two governments.

With respect to what we face in terms of the possibility of German classification there appear to be no legal obstacles to their doing it. In our discussions it became quite clear, based on statements of their Justice Department people and others, that they can under their existing law impose classfication and they can also impose export controls over materials. They pointed out, however, that there are several things that we must bear in mind. I think that in some respects we were probably more sensitive to the political and psychological aspects of this than they.

On the economic side of the problem which they face is a matter of investment by their scientists and by their industry in developing the process. If classification is imposed, the question is immediately raised about what will happen with respect to the commercial advantages that

might accrue as a result of investing in the process. This is a matter that presumably they are considering at this time. They did not go beyond the point of just raising it as a possible problem, but they did indicate they thought they might be able to deal with it.

REPRESENTATIVE HOLIFIELD. Of course this is the problem that occurs in the United States when anything is classified. It does deny to the manufacturers the commercial rights and this is done on the basis of preservation of the government. They have just as much of a stake in preserving their part of the free world as we in preserving ours. I suppose the next thing they will be asking is for us to pay their firms not to produce these things or to let them out throughout the world.

MR. SULLIVAN. They merely mentioned this as a problem they would have to deal with and they did say it was something that was up to them to handle and they felt -- in fact, stated very clearly that they thought the potential of the centrifuge process was such that there were overriding security considerations both from their standpoint and from ours.

CHAIRMAN ANDERSON. But they did want money.

MR. SULLIVAN. No sir, they did not mention that as a specific point. They mentioned this as a problem that would have to be handled, but they did say that it was their problem.

MR. RAMEY. Did they suggest a joint research effort with them in the development of the centrifuge process on a classified basis?

MR. SULLIVAN. One of the questions they raised was whether by imposing classification on their developments in this research would preclude cooperation with the United States, in this. Our answer to that was that we would have to take that up back in Washington; that we were not prepared to discuss at this time but would like to know whether they were proposing it. That was the way we put it to them. Their response to that was that there were not proposing it; they were merely raising it as a point for further consideration.

CHAIRMAN ANDERSON. Aviation Week for August 29 carries an article,

"German Army Wants Nuclear Warheads". It said, "NATO sources indicate the Germans are thinking in terms of a joint-control system placed under NATO command." I wondered if this had any tie-in with this other suggestion.

MR. SULLIVAN. I would say not, Mr. Chairman. My reason for saying that is the German Atomic Energy people were very sensitive on the point of classification in that they emphasized that the entire German effort in the field is directed at future peaceful uses. As a matter of fact they registered some concern that if classification was imposed in Germany on the basis of the security problems involved that it was very likely their scientists and possibly their industry would lose interest in the process because they did not want to be connected

in any way with military applications of atomic energy.

MR. RAMEY. Apparently their army doesn't agree.

MR. SULLIVAN. Yes, but under the WUEU conditions Germany is prevented from producing nuclear weapons and apparently --

MR. RAMEY. At this time.

MR. SULLIVAN. At this time. They indicated that -- that is, the Atomic Energy officials whom we discussed this with - both their scientists and their industry were not at all interested in this subject and they didn't condition that in any way.

REPRESENTATIVE HOSMER. What is their interest in producing U-235 if it doesn't have anything to do with weapons?

MR. SULLIVAN. They are interested in the process for possible peaceful applications. The specifics of that I think someone else would have to give.

COMMISSIONER WILSON. Fuel for power plants.

SENATOR PASTORE. How expensive is this endeavor anyway? Is it a large project or is it confined to two or three companies where it could be negotiated and whatever research that goes on would be under the government by private companies the way we do it here? Is it on a small scale or a large scale? Do we know that?

MR. SULLIVAN. Apparently modest. There are only two firms that are fairly directly interested in this.

DR. KOLSTAD. Degussa and a German General Electric AEC in Frankfurt are the two industrial firms concerned with it. There is other work going on at the University of Bonne at North Rhine-Westphalia Research Center which is a sort of national laboratory in Germany under Beyerle. Then there is a third effort at the University of Kiel on theoretical aspects. It is about twice the level of effort of the U.S. -

COMMISSIONER WILSON. The present effort.

CHAIRMAN MCCONE. Twice the present effort.

COMMISSIONER WILSON. Not twice the proposed program.

REPRESENTATIVE VAN ZANDT. Mr. Sullivan, assuming you are successful in negotiating an agreement between the three nations, what about Brazil?

MR. SULLIVAN. As I understand it the centrifuge that was sold to Brazil by the Germans is a comparatively -- slightly obsolete in terms of what we are talking about in the ~~actual~~ ultimate system and I don't believe there is any particular concern there with respect to the capability of the Brazilians to develop that on their own to the point where they could produce weapons.

REPRESENTATIVE VAN ZANDT. Are the 7 that have been sold to a U.S. firm of similar design?

DR. KOLSTAD. No sir. The ZG-7s are advanced and these are the ones that are to be sold to Westcliff.

REPRESENTATIVE VAN ZANDT. What you are trying to classify here then is the advanced development in the field.

DR. KOLSTAD. Exactly.

MR. SULLIVAN. I would say, sir, what we are trying to classify are any further developments. Developments to date have been pretty much released and I think they are available.

COMMISSIONER WILSON. That is not true of the University of Virginia work.

MR. SULLIVAN. I am sorry. I meant primarily with respect to the Germans. It is not so true with respect to the Dutch. The work of the German scientists has been quite open.

SENATOR GORE. Mr. Chairman, would it be reasonable to conclude from this development that West Germany may be well along the way to becoming a nuclear power?

CHAIRMAN MCCONE. I don't think you could conclude that, Senator Gore.

SENATOR GORE. Would it be reasonable to conclude they are well on the way toward the production of U-235?

CHAIRMAN MCCONE. I think if they pursue this further they will have the facilities for producing U-235, but I know of no activity of theirs or intention on their part to actually produce weapons grade U-235 or to carry from that point on to weapons.

SENATOR GORE. That leads to my next question. Just how dangerous would it be if Cuba had one of these plants that would produce U-235? Are they still a long way from producing a weapon?

GENERAL LUEDECKE. About eight years.

CHAIRMAN MCCONE. Yes, they are because the production of the weapon is not an easy thing to do, as you know. However, it is a technology that is quite widely known and is becoming more widely known all of the time.

SENATOR GORE. That is the question I was coming to. This, at first blush, certainly gives me an uneasy, uncertain, almost frightening feeling for the world when you consider the irresponsible people who have come to power through coups and otherwise. Just how would you compare the effort to produce a weapons grade uranium and then the development of a weapon, maybe not of the refined type, but a weapon. Any kind of a nuclear weapon is dangerous.

CHAIRMAN MCCONE. You mean in terms of years?

SENATOR GORE. In industrial technology.

CHAIRMAN MCCONE. I think that a country that set out to produce the U-235 through a complex of these centrifuges and recruited the technical skills to do that could very probably recruit the skills necessary to make a primitive weapon.

SENATOR GORE. And the time factor would be what?

CHAIRMAN MCCONE. The time factor is a matter of -

CHAIRMAN ANDERSON. If you get a chance -

CHAIRMAN MCCONE. There is a chart there that shows what the estimates are.

SENATOR GORE. What I was trying to get is a comparative time factor. Let us say that Sweden wanted to start out to become a nuclear power and they undertook to recruit the skills necessary to do both of these actions.

CHAIRMAN MCCONE. I will answer that, Senator.

SENATOR GORE. I am sorry. You may have gone over this before I came in.

CHAIRMAN MCCONE. I would class Sweden as a Class X power. If they wanted to depend on today's technology, which is the 300 meters per second peripheral speed, then they could produce a weapon in just under five years. If they wanted to wait on the technology which apparently can be accomplished now, but would take, maybe, three years to perfect all of the details of it, just under five years still holds but you must add to that the development time which is roughly 3 years so it would be 8 years. A less developed country, a Class Z country, which is Cuba, you might have 8.2 years and 11.2 years.

SENATOR GORE. That still hasn't come to the question of the weapon itself.

CHAIRMAN MCCONE. Yes.

SENATOR GORE. You mean both?

CHAIRMAN MCCONE. That is to produce the first weapon.

COMMISSIONER WILSON. The plant could be built in a little less.

SENATOR GORE. I see.

COMMISSIONER WILSON. That is assuming you work together simultaneously on both weapons technology and the plant.

REPRESENTATIVE PRICE. Are you considering it entirely with their own resources and their own personnel? What if they were assisted by, say, the Russians?

DR. KOLSTAD. This assumes they are assisted.

SENATOR GORE. Mr. Chairman, I have one other question and then I shall desist. This is indeed confusing -- to use an under phrase, sobering. Other than the existing nuclear powers, with your knowledge of the industry and the capacity of the various nations, what other nation would you estimate to have this capacity to the extent of Y -- Italy?

CHAIRMAN MCCONE. By all means.

COMMISSIONER WILSON. Most of the European countries.

CHAIRMAN MCCONE. The X countries are considered by the authors of the report, which is Union Carbide Company, to be Austria, Holland, Belgium, Switzerland, Italy, Japan, Sweden, France, West Germany, the United Kingdom and the USSR. The Y countries -- the middle countries -- are India, Israel, Yugoslavia, Chile and Brazil. The Z countries are such countries as Pakistan, Peru, Egypt, Turkey and Cuba.

SENATOR PASTORE. Where is Red China? That is still your biggest threat of all.

CHAIRMAN MCCONE. I guess they left them out because they weren't members of the U.N.

SENATOR PASTORE. That is ridiculous. We keep worrying about our friends more than we do about our enemies.

DR. KOLSTAD. I would put it as a Y country.

SENATOR PASTORE. You would?

CHAIRMAN MCCONE. I don't know as I agree with that.

SENATOR PASTORE. I would put it in X.

CHAIRMAN ANDERSON. Before we get away, I wonder if I could ask you about this Nucleonics article. On August 4 Nucleonics Week published an article - "West Germans Agree To Put Secrecy Lid on Gas Centrifuging -

"The U. S. has has persuaded West Germany to veil in secrecy the gas centrifuge isotope-separation technology under development in that country, according to authoritative sources. West Germany is the noncommunist-world leader in this approach to producing enriched uranium, with at least two active programs (Degussa and Prof. Wilhelm Groth have both built developmental machines.) The U.S. has a small AEC program and considerable commercial interest (NU Wk, 7 July '60,2) but appears to be well behind West Germany. Centrifuge research-development is also being carried out by the Brazilian government (using three German built machines) and the Univ. of Amsterdam, Netherlands.

"The U.S. plea to shroud centrifuge development in West Germany was transmitted at the very highest diplomatic level. The action reflects deep U.S. concern that: 1. centrifuge know-how and equipment may spread to other nations and give them nuclear weapons capability; and 2. that the technology should be at least informally close-held until formal international control can be arranged.

"AEC has been on the verge of classifying all centrifuge technology in this country earlier this year (NU Wk, 19 May '60, 1) but has not yet followed through. The Commission's course of action is under study. The secrecy policy is creating a governmental dilemma for West Germany because there is no legal grounds for shutting off discussion. Either centrifuges are purely for peaceful uses, in which case no secrecy can be enforced by the government; or the centrifuges have military importance, in which case Germany cannot carry out work in this field without violating post-World War II pledges on nuclear capability."

It goes on to say,

"On the other hand, the situation is further complicated by the desire of German firms to work out cooperative and exchange programs with U.S. firms (Groth has given Thor-Westcliffe, Inc., of Santa Fe, N.M., exclusive North American rights to his process, for example). Classifying the U.S. partner's work would not work out unless the German work was also classified. Informal 'trade secret' arrangements would also appear to be impossible in the nuclear field because the German partner would be in violation of Euratom regulations."

I know that Thor-Westcliffe is a Santa Fe firm. I do not know what its arrangements are with Germany. If they start to sell these things and if they are shipping into the United States, how do you propose to start classifying it? Do you go to somebody and say, You forget you ever bought a machine. Just put a blanket over it."?

MR. SULLIVAN. Again, Mr. Chairman, I believe we have to think of this in terms of the future and not what has been done to date. In terms of the developments that are likely to come about and there have been rapid developments here in the United States in terms of research, it is quite important that some means are found to control that so it is not disseminating throughout the world. With respect to export or

sale of equipment or the materials, for that matter, a means must be found to put controls on that so it does not go to any country that wants to buy it such as Israel or UAR, ~~I believe~~. We are exploring, as ~~a matter of fact,~~ at this time the methods of control.

If we get the Germans and Dutch to put immediate controls on the information by classifying so that it does not diesseminate outside of their countries unless there is a special agreement, we must then consider export control over the equipment that might be produced. This is a difficult problem and it gets into one of the basic psychological problems that both the Germans, and, I think, we must face. We must deal with this matter of putting a security classification on a process which will not be directed solely at the Soviet Bloc but will include our allies as well -- German allies. This will get quite sensitive.

It gets down to a question if they do impose classification of what are the conditions under which they might agree to cooperate with another government. The Dutch are already in the business and are doing a great deal of research so I think there is a logical basis there but questions immediately arise. Suppose the French want to get into a large scale program of this sort. How is that handled?

CHAIRMAN MCCONE. And they do want to get into it.

MR. SULLIVAN. Yes.

REPRESENTATIVE HOLIFIELD. You spoke of the classification of materials or the banning on export of materials. Are there unique materials involved in this which are not of wide availability?

MR. SULLIVAN. No, but if the Germans do produce uranium there is a question of whom they should export it to for reactor purposes.

REPRESENTATIVE HOLIFIELD. You weren't speaking then of materials in the centrifuge so much as of the weapons material.

MR. SULLIVAN. I really meant both the export of material, the uranium that might result from the process and the process itself because of the technology it contains.

REPRESENTATIVE HOLIFIELD. We are working in the centrifuge machinery with known and available material in the industrial world?

COMMISSIONER WILSON. The University of Virginia has really worked with some very special materials recently that aren't generally available.

REPRESENTATIVE HOLIFIELD. Then let me rephrase my question. It is evident that these materials were not necessary to the Germans to get to the point of technology they are now at, but you may need additional materials to go further. Is that right?

MR. SULLIVAN. That is right.

MR. MARSHALL. Lest there be a misunderstanding on that point, I think it is important to note the materials over which we hope to

impose control is not the product or material that you classify; not the U 235 because that is unclassified; but the materials of construction of the centrifuge and the design of centrifuges themselves.

REPRESENTATIVE HOLIFIELD. That is what I was directing my question to.

MR. MARSHALL. I was afraid the answer may have left some doubt in your mind.

REPRESENTATIVE HOLIFIELD. The answer did leave doubt in my mind. Now I will go back and ask you whether there are any unique materials involved here which can be classified or is it the shape or designing or processing of the materials?

DR. KOLSTAD. There are high speed bearings that are necessary for the operation.

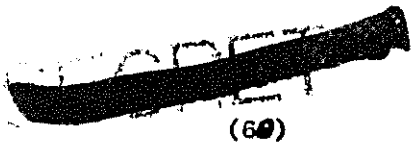
REPRESENTATIVE HOLIFIELD. Is that made out of available material?

DR. KOLSTAD. It is not the material in this case but the design of the bearing that would be classified. There are high speed motors and drive systems which would be classified.

MR. MARSHALL. And the design of the centrifuges themselves.

DR. KOLSTAD. Yes.

REPRESENTATIVE HOLIFIELD. Have you advanced or have these people advanced quite a ways above the known industrial technology on these points?



(60)

DOE
b.2(a)

DR. KOLSTAD. DELETED

This is an advance beyond known technology.

COMMISSIONER WILSON. That is the University of Virginia.

CHAIRMAN ANDERSON. Is that far beyond what they were going to sell to Thor-Westcliffe?

DR. KOLSTAD. Oh yes. The ones that were sold to Thor Westcliffe would operate between 325 and 350 meters per second.

REPRESENTATIVE HOLIFIELD. Is that sufficient speed to do the work of separation?

DR. KOLSTAD. Yes.

REPRESENTATIVE HOLIFIELD. Even though it does it less efficiently.

DR. KOLSTAD. That is right.

REPRESENTATIVE HOLIFIELD. You are just talking in degree when you talk about classification beyond 350.

MR. MARSHALL. Yes.

CHAIRMAN ANDERSON. If Israel were to buy one like that sold to Thor-Westcliffe, it could make U-235.

MR. MARSHALL. If they can purchase them from Germany. Presumably the techniques of making these things is still not widely available.

CHAIRMAN ANDERSON. I said if they can purchase a machine from Germany like the one which Germany agreed to sell to Thor Westcliffe, they could go ahead and make U-235.

COMMISSIONER WILSON. If we get the government to classify and put export controls on it, then they couldn't buy them from Germany.

CHAIRMAN ANDERSON. Is there any way you can classify the one that has already been made available?

DR. KOLSTAD. No, but export controls could apply regardless of the classification.

CHAIRMAN ANDERSON. Didn't they ship one to Brazil?

DR. KOLSTAD. That was some time ago.

COMMISSIONER WILSON. It is still lower than 300.

CHAIRMAN ANDERSON. Are you going to take it back? You said that with 300 they can make uranium. Are you going to take the one back from Brazil?

MR. MARSHALL. No, you couldn't do that -

REPRESENTATIVE PRICE. Brazil would have to be a party to any agreement -

MR. MARSHALL. Mr. Price, may I make a comment at this point about the reasons why classification was to be put on and what we hope to accomplish with it.

For Senator Pastore particularly on China, although Carbide neglected China in their report, China was far from neglected in our consideration of the importance of this program to the future and safety of the world. China was at the forefront, I might add. What we hope to accomplish is this. We knew the Germans and Dutch were both working

in this field. We knew also that their work was about at the same level as ours.

We knew at the time we put a classification on ours where we were and that indications were beginning to come out this would be a really good process. We imposed classification on ours right away because we were in a position to do so. We also recognized we could not successfully classify any of this work unless we could get the cooperation of the Dutch and Germans and we attempted to do this with the aid of the State Department to get their cooperation.

We understood that the Germans were publishing and so far as I know they were publishing right up to the time of this meeting. They may still be. I don't know what their situation is at the moment with respect to publishing their work but we knew they were publishing articles, that they had sold 3 centrifuges to Brazil and they had contracted some to Thor-Westcliffe. But the Brazilians do not know how to make the centrifuge. Neither does any other country outside of Germany, outside of the Netherlands, outside of the United States and possibly Russia.

SENATOR GORE. May I ask a question? You said two things about Brazil. One that they have purchased three and second they do not know how to make them. Can't they use the ones they bought?

MR. MARSHALL. It is possible they could use the three they have bought; true.

COMMISSIONER WILSON. That would get them nowhere.

SENATOR BENNETT. How much material could they produce with three?

MR. MARSHALL. With those three, very little. Actually I don't know how much.

SENATOR GORE. How long would it require for them to produce enought for a weapon?

COMMISSIONER WILSON. Twenty years; thirty years.

DR. KOLSTAD. With the three units they have, it would take many years. This is not an industrial number at all. It is merely a laboratory device.

SENATOR GORE. They have been talking about a thousand in 1300 units.

SENATOR GORE. Do you mean Brazil is incapable of reproducing something she has purchased?

MR. MARSHALL. I think at the moment this is probably true. These are not the easiest things to produce.

SENATOR GORE. Is lack of maching tooling, bearings?

MR. MARSHALL. Lack of knowledge.

What we hope to accomplish with this is that the Germans will stop exporting their knowledge and stop exporting their materials.

REPRESENTATIVE HOLIFIELD. Actually the man who came to this country, Dr. Zippe, had been previously building centrifuges for the Russians. In the rocket technology the Russians released the rocket people and sent them away after they found out everything they knew and then went on with the development themselves. The impression is they have pretty good rockets.

Here the Russians learned everything Zippe knew and turned him away. We took him and had him teach us how to do the work. Isn't it a fair assumption that the Russians know all there is to know about it and they can give it to Red China?

CHAIRMAN MCCONE. Certainly they know all about this. What is unknown is the extent to which they pursued it after they turned the Germans loose.

There is another point I would like to make. I have followed centrifuges, not this type, but of other types of centrifuges for a great many years and I have learned one thing. That is that there is continual improvement and grown and betterment. Furthermore I have observed the industrial capacity and skill and quality of materials available in several countries, most particularly Switzerland and Sweden and they have the capacity to get into this business if they should desire. So this is an extremely difficult and it might be an almost entirely impossible thing to bring under control. I think it is worth trying.

[redacted]

CHAIRMAN ANDERSON. I agree with you.

SENATOR PASTORE. I am sorry, Mr. McCone, that I wasn't here in the beginning. What is the purpose of this meeting here today?

Is there any question in anybody's mind as to whether we should try to classify this with our colleagues?

CHAIRMAN ANDERSON. It is simply I thought it would be a good thing to bring the members of the Committee up to date in this very important field. I think this is a very important piece of work that the AEC and State Department are doing. We might be asked suddenly to give them help along the road. I wanted to be sure we knew what they were trying to do because it would be pretty hard to explain why they were trying to classify something that was in general use unless you sat in on the meeting this morning and heard the story.

SENATOR GORE. It has been a very helpful meeting.

SENATOR PASTORE. The possibilities are horrifying. What level are we negotiating with the Dutch and the Germans? The highest level?

CHAIRMAN MCCONE. Right.

SENATOR PASTORE. Are we at the top echelong or where are we?

MR. SULLIVAN. In Germany it was the Deputy Director of their Atomic- [illegible],

SENATOR PASTORE. Deputy director?

MR. SULLIVAN. The Minister was not available. That was the only reason we did not meet with him.

[redacted]

Draw from 66 page

I might say, Senator Pastore, the Germans before we left made it very clear that this matter had been discussed between our two meetings all the way up to the top of their government. Furthermore on one occasion there had been mention of the concern over the potentials of this process at the highest levels between our respective governments.

CHAIRMAN ANDERSON. Was there any kickback on the Nucleonics article that outlined in advance what the program was?

CHAIRMAN MCCONE. Yes. We thought the article was very unfortunate.

CHAIRMAN ANDERSON. I thought the article was unfortunate. What disturbed me most was the fact the article was dated August 4 and appeared in print before the first of August and we got a long letter from you about August 3. If one didn't take a look at the time they printed it, you would think we just took your letter and published it to the world.

CHAIRMAN MCCONE. Yes.

CHAIRMAN ANDERSON. Actually your letter arrived here after this Nucleonics Week article. I think it is extremely unfortunate this article got out and was, as I thought, as well done as it was.

I think we ought to move to the other subject Mr. McCone wanted to discuss. Are there any people you want out of the room?

(Whereupon at 12:06 p.m. this portion of the meeting was concluded.)

This document consists of 7 pages

Copy No. 1 of 50 Series A

[redacted]

TESTIMONY OF JOHN A. MCCONE, CHAIRMAN OF THE AEC, BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY HEARING ON THE GAS CENTRIFUGE PROGRAM

In the early days of atomic energy development, the centrifugal method was one of the processes considered for economical, large-scale uranium isotope separation. However, because this process was not so far advanced as alternative methods, development of the gas centrifuge was discontinued in 1944 and effort was concentrated on the processes which were employed in the wartime plants.

Information on the development efforts underway in other countries and a new analysis of the potentialities of the process led to a resumption of effort in 1953 by the United States. The Commission, under the Division of Research, has since that time supported a modest research program with the intent of conducting basic studies on the technical and economic merits of the process and the problems of high speed rotational motion released to the improvement of the gas centrifuge unit. This classified program has benefited substantially from the presence and advice of Dr. Karl Cohen and Professor Jesse Beams who have played leading roles in the key developments in the gas centrifuge program for many years. The effort at the University

[redacted] DATA

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmittal or the disclosure of its contents in any manner to an unauthorized person is prohibited.

of Virginia combined with the analysis made at the Walter Kidde Nuclear Laboratories has resulted in significant improvement in the outlook for the technology of the gas centrifuge method of isotope separation. Among the major achievements at the University of Virginia has been the solution, in 1957, of the problem of spinning a long tube through a series of critical vibrations, a problem inherent in high speed rotation.

During recent years, a considerable portion of the effort has been devoted to the problem of operation of units at higher speeds. Since the separative capacity of a unit varies as the fourth power of the peripheral velocity, there is a decided advantage in higher speeds. For example, by doubling the peripheral speed, the separative capacity will increase by a factor of 16.

Along another line of attack, the Division of Research also arranged for the conduct of a short-bowl gas centrifuge program at Virginia under Dr. Gernot Zippe, an Austrian national, who was a member of a German scientific team recruited to develop such centrifuges for the USSR. The short-bowl centrifuge method avoids the critical vibration problems encountered with long tubes. He has reproduced for us this short-bowl centrifuge and has demonstrated the operation of the unit in the separation of uranium isotopes. The simplicity of this short-bowl unit, coupled with the materials improvements developed in the US missile and other programs, indicates the feasibility of design

of a short-bowl unit having considerable potential for plant-scale isotope separation.

The Commission, in recognizing the advances taking place at the University of Virginia, as well as the effort in this area underway in both West Germany and the Netherlands, arranged for a technical and economic analysis of both the long and short-bowl methods. A report analysing the short-bowl method was completed in January 1960; the long-bowl analysis has been completed and the report is expected to be available in the near future.

The results of the short-bowl study, along with the results of some special studies undertaken at my request, indicated that the gas centrifuge process at the higher speeds now believed to be attainable and the current design simplicity offer the possibility for additional nations more easily to acquire nuclear weapons materials, within, perhaps, the next decade. In view of this potential N^{th} power problem, I deemed it necessary to have the Departments of State and Defense, CIA, and the Joint Chiefs of Staff briefed on the gas centrifuge method of isotope separation and the potentials of the process. Also, in view of the seriousness of the problem, I discussed the matter with the Secretaries of Defense and State as well as bringing it to the attention of the President. A report covering this subject was provided to the Joint Committee.

Meanwhile, in October, 1959, I had occasion to meet with Sir William Penney, UKAEA, at which time we discussed our mutual

[redacted]

concern over the potential military significance of the centrifuge process, which can be used to produce weapons grade material as well as slightly enriched material for commercial purposes. We concluded that the present level of effort on the process in both our countries should be increased. Industrial and university groups in both West Germany and the Netherlands were pursuing studies of this process with vigor, and the Germans were continuing to publish in the open literature the results of their investigations. A small-scale theoretical study is being conducted by the U.K.

The Commission has taken a number of steps, about which you have already been advised, to keep technologically abreast of the potentials of the process and to minimize the possibility of additional nations' acquiring a nuclear weapons capability by means of this process. In order to accomplish these ends, we have approved an expanded three-year research and development program, estimated to cost a total of approximately six million dollars. Provisions for this program have been made in our current financial plans and we expect to proceed shortly with this expanded effort.

Concurrently, there has been considerable interest expressed by a number of U. S. industrial companies to be permitted to develop the centrifuge process with private funds. Recognizing the sensitivity of this area of development, the Commission has

[redacted]

studied the problem of private industrial development and has indicated agreement in principle, to permit industry to engage in the development of the gas centrifuge method of isotope separation with private funds under the access permit program and under appropriate conditions and security. Before taking final action on this matter, however, we wish to consider the views of the Departments of State and Defense. To assure meeting our own objectives, it is intended to proceed with the planned Commission program even in the event of privately financed undertakings in this area, although some adjustment in scope or content may be required in view of the private efforts. Appropriate liaison between the private and government programs would be established and maintained.

With regard to classification, it had been our policy to conduct the gas centrifuge work as a classified program, but to declassify the resulting information after an evaluation of its significance to the national defense and security. When early in December, 1959, these reviews indicated that the U. S. efforts had made significant progress in the technology of the centrifuge, and the indication of the potential value of the gas centrifuge as a plant-scale method of separating uranium isotopes began to appear, we concluded that strict classification should be retained. The work conducted at Virginia by Dr. Zippe, which repeated work he previously performed for the USSR, was carried out on an unclassified basis.

[redacted]

Cognizant of the fact that any classification action taken by the Commission could be vitiated if the German and Dutch activities were to proceed on an unclassified basis, we consulted with the Department of State on the feasibility of discussing with the German and Dutch governments the possibility of their classifying their work and/or taking any other action necessary to control the dissemination of data, materials, and equipment. As we advised you by letter dated August 3, these discussions have now taken place with the U.K., German and Dutch governments. The representatives of these nations with whom our people talked have agreed with our assessment that the gas centrifuge process offers the possibility for additional nations to acquire nuclear weapons materials and have recognized the desirability of achieving uniform classification policies and practices within the four countries having gas centrifuge research and development programs. There are, however, as reported to the Committee in our letter of August 3, certain psychological - political difficulties to be overcome. All four countries will continue to be in touch through diplomatic channels in order to establish an agreed course of action with respect to classification and to explore further the possibility of cooperation. Mr. Charles Sullivan of the Department of State is here today and will be able to discuss the details of the recent visit to Europe if you wish. The Committee has been

[redacted]

informed by our letter of August 4 of our planned cooperation with the U.K. in this area.

I have attempted to touch briefly upon our major problems and to point out that significant advances have occurred. Much detailed information has been provided to the Committee in the form of technical reports from the Commission's contractors as well as from the Commission staff and in letters to the Committee regularly reporting on major topics.

As you no doubt recognize, Dr. George A. Kolstad of the Division of Research has been intimately associated with the gas centrifuge program; he is with us today, prepared to provide you with a further report on the technical programs in this country and abroad. Following this presentation, I shall be happy to answer any questions you may have.

Thank you.