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TAPE RECORDED INTERVIEW PROJECT

Interview with Robert C. Bundgaard
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Interviewers: Diane Rabson, Melvin Holzman

Rabson: This is Diane Rabson. It's Wednesday, September 16, 1998. We're doing an interview with Bob Bundgaard for the AMS Tape Recorded Interview Project at Foothills Lab at NCAR in Boulder, Colorado. The interviewers today are Mel Holzman and Diane Rabson.

Good morning, Bob. The first question I would like to ask is when and where you were born, and could you talk a little bit about your family of origin.

Bundgaard: Thank you, Diane. Believe it or not, I was born here in Colorado, in Denver, and I grew up in Denver. My parents were immigrants to the United States from Denmark. My mother came to the United States when she was 15 years old, alone, and [there were] some fascinating experiences in her journey over here at that age because, among other things, she hadn't yet learned to speak any English. My father came separately and he came directly to Denver. I was born on July, 14, 1918, at the end of World War [I]. At that time, my dad was in military service and he was at Key West helping in construction of some Navy operations then.

Rabson: Do you want to tell us about school--subjects you liked, teachers and any kind of influence or interest in science. I know you had a very strong interest in music.

Bundgaard: My two interests in school were in mathematics and music. My interest in mathematics is probably what got me into meteorology. I went to the University of Denver in 1936. During the summertime, I worked on Mount Evans in an observatory for several men; one was [Robert] Millikan, from Caltech, and another man named Vroman, from the University of Chicago, and the third man was named Joyce Stearns, who was the chairman of the physics department at the University of Denver. The work at that time was on radiation studies. My job there the first summer was to manage the reproduction of fruit flies, the *Drosophila* fruit flies. And I think we were able to get fourteen generations during the summertime. One group were kept under lead plates, protected from the radiation, and the other was exposed to the radiation. The purpose of the

study was to find out what mutations would take place in the fourteen generations of fruit flies during that summer at that high altitude.

Rabson: What did you discover?

Bundgaard: We used the counters and we discovered that we had about 22 particles going through the human body on top of [Mt. Evans], as opposed to 6 per second down on the campus at DU. So altitude made a lot of difference. We also discovered there was a mutation in the fruit fly; I can't remember how many generations out, but I think they began to be born without wings and there were some without legs, and I think some were decided that they were blind. So there was a mutation effect due to the gamma radiation and the beta particles.

Rabson: Tell me a little bit about high school in Denver and any influences there.

Bundgaard: I went to South Denver High School, and I was there from 1933-36. This was as you probably remember during the Depression era, and I remember that my parents were out of work, but things seemed to go pretty well. My interest was mostly in music at that time and I was studying the violin from a man named David Eisenberg. Sometime before the end of that period I was invited to join first the Denver Civic Symphony Orchestra and then the Denver Symphony Orchestra as a violist, and I think the director at that time was Horace Turman. And they ended up one September short of violists so they got to me to sit in. And I stayed with the two symphonies up until the beginning of World War II.

Rabson: You got a Bachelor's degree from the University of Denver, and then you got your Master's. Talk a little bit about your Bachelor's first and then what you did your Master's in.

Bundgaard: I was in the liberal arts college at Hilltop [Denver University], which is out at University and East Evans. I had two majors: one was in mathematics and the other was in physics. My work at Columbia University was in probability theory, mostly related to educational testing.

Rabson: Even with your interest in your music, how did you end up in math and physics? What did you hope to do with your degrees?

Bundgaard: Well, I'm not quite sure what my interest was. I always had a tug-of-war with my parents in taking subjects that were not considered "practical." When I was in high school, I took four years of Latin, and that was much to my mother's unhappiness, because she thought if I took a good course in typing, it might be much more practical. But I enjoyed my four years of Latin--it was one of my best courses that I took in high school.

And I really don't know what my objectives were in mathematics, but simply that I enjoyed it. I think it came primarily by having met Joyce Stearns, who was a

remarkable man who led [me] to a great deal of inspiration in my choice of mathematics.

Rabson: So you got your master's from Columbia and at some point--this is in the 1940's--what were you doing then? Didn't you become a schoolteacher after that?

Bundgaard: Yes. In the summer of 1940, by a bit of a surprise, I got a job as band director of Douglas County High School, which was located in Castle Rock. Up until that point, I hadn't done much in the way of band music and had done practically nothing in the way of conducting. So I did a crash self-improvement program and then I was at Douglas County High School until early 1942, when I got drafted into the Army Air Corps. And at that time, I had the high school band, the junior high school band and the grade school band. Then, in addition to that function, I also taught math and believe it or not, biology, at the high school. It was a small consolidated high school for Douglas County. I think at that time there were less than 500 students in the high school. It was a great time, one of the happiest and most fascinating that I ever had.

Rabson: You got drafted. Tell us what happened after that and where you ended up.

Bundgaard: I came up to Denver and got sworn in at the Post Office and was put on a train and the train went down to Los Angeles and I got off there and went to school as an aviation cadet at UCLA. This was in March, 1942.

Rabson: How did you end up in that program in particular?

Bundgaard: I hadn't thought about it except that I got a telephone call from Joyce Stearns, who was the chairman of the physics department at the University of Denver. He had become involved in a training program for the military even though his background had nothing to do with meteorology. He told me about the program, the aviation cadet program in meteorology, and he recommended that I look into it. So together with him, I looked into it. And we decided that that might be a good thing to apply for, so I applied for that program.

Rabson: Let's talk a little bit about that program at UCLA. Who were your teachers and what kinds of courses did you take, anything you want to say about that program.

Bundgaard: This was the third class in aviation cadet meteorology at UCLA. Our primary instructor at that time was Jac Bjerknes; another instructor was Jorgen Holmboe, and a third instructor was Morrie Neiburger. They were the main instructors. On the staff we had Will Kellogg and also Joe Kaplan, who was at that time head of the department of physics. His teaching was mostly in radiation theory. But then on certain occasions people would come over from Caltech and lecture to us. Two of those people from Caltech were Benno Gutenberg, who lectured on atmospheric propagation, both sound and other radiation program, and I think on two occasions, Irv Krick came over from Caltech to lecture to us. There were two other instructors; one was Professor Sverdrup, who came from Scripps, which

was part of the University of California program, and the other was Walter Munk, who was also at Scripps at that time. It was a marvelous group of instructors.

Rabson: I'm interested in what Irv Krick taught, and what you learned about his forecasting techniques.

Bundgaard: Most of these presentations that were given by Irv Krick at UCLA were overviews--there was very little instruction given in the basics of forecasting from Krick. At that time, there was kind of a respectful separation between UCLA and Caltech. The emphasis that UCLA by the Norwegian instructors was that unless things could be put on a physical basis it didn't merit being a part of the curriculum. And they felt that some of the ideas that Krick was proposing and putting forward lacked a physical foundation. So they were looked at a little bit askance.

I remember one student one time who was trying to enlighten the presentation a little bit; he approached Professor Bjerknes, who was a very gentle and kind and good person, and handed him a paper that Krick had recently published. He asked Professor Bjerknes what he would think of this paper, what he thought of it. And Professor Bjerknes looked at him very quietly and was a little anxious about what he should say. He finally uttered, "Well, I think this is a paper that will not long be remembered."

Rabson: Did you have any kind of model weather station that you worked with, or did you work with teletype data, current data?

Bundgaard: We had a complete weather station on top of the physics building and part of the training program for the cadets was to learn how to make and take weather observations. We did not have any teletype at that time, but we had synoptic maps that had been printed and pre-prepared from earlier historical data. So we did weather map analysis from the periods of time that were before the current time. So we took current weather observations, but this was also during World War II and weather observations were not publicly disseminated nor were forecasts made. So we didn't have access to current weather.

Rabson: Is there anything else you want to say about your UCLA curriculum? You were in the third class? That started in 1942; how long was the course?

Bundgaard: The class went from early March, 1942, until late November, 1942. There were some outstanding fellow cadets in the class. One of the persons in the class was George Forsythe, who was already a mathematician from Philadelphia and a Quaker, and he later headed the department of mathematics and computation at Stanford. He later stayed on at UCLA as an instructor and he co-authored a textbook with Holmboe. There were other outstanding people in that class, too.

Rabson: Jule Charney?

Bundgaard: I forgot to mention that Jule Charney was also--I think he was in the earlier class, probably class number two, and was an instructor there. I later had a chance to become better acquainted with Jule Charney when I was studying in Norway. He was also living in Norway and studying--he was at the University of Oslo, and I was at the Geophysical Institute in Bergen. So he and his wife and our family became rather well-acquainted during that period in Norway. Then I later had a chance to work with Jule Charney in Princeton, with von Neumann, when the first numerical programs were being set up on the ENIAC computer there...so I spent probably half a summer with Jule Charney in Princeton. That was probably in 1951 or thereabouts.

Rabson: Was Phil Thompson there when you were there? This would have been the Institute for Advanced Study.

Bundgaard: I don't think Phil Thompson was there at that time. I'm beginning to think now that my time at Princeton was in the spring of 1949, 1949-50. I don't think Phil was there at that time.

Rabson: We can get to that after you tell us your wartime experiences.

As I understand it, after UCLA did you go directly to the Pentagon Weather Central or was there something else intervening?

Bundgaard: Right after UCLA, I had a short tour at an air base in Pueblo, Colorado. I think I was there only for about three weeks. It was the wing; I worked at that time for a person named Hazen Bettge. He later became regional RCO for the National Weather Service for the Western Region. It was the beginning of a very good long relationship with Hazen, whom I respect a great deal.

Rabson: Do you want to tell us about your experiences at the Pentagon?

Bundgaard: When I came to Washington, I reported to Colonel Merewether and at that time, his offices were over at 24th and M Street, which was the Weather Bureau office at that time. And shortly thereafter, we moved into the Pentagon, which was still under construction. We moved up to the fourth floor. We had a group there called the "Directorate of Weather," which came under the Army Air Corps staff Director of Operations. In the Weather Central, there were Joe George, Ben Holzman was there and Ken Spengler, and from time to time, Irv Krick was there. We had an operational forecast center. The surface section was run by a civilian named Mr. Day. In addition to that, they set up four long-range forecast sections. They were given the letters "LRFA"--Long Range Forecast Unit A--LRFB, LRFC, and LRFD. The LRFA was organized by Irv Krick and was made up of people from Caltech. It was subdivided into two groups. One group was physically located in the Pentagon, and the other group was located out at Caltech. I was assigned to a group called "LRFD," which was a statistical forecasting technique based on the work that was being done by George

Wadsworth and Ken Spengler at MIT. That was my main function. Then at that time I was sent over to the Weather Bureau, and I worked for about eight months with a man named Mitchell. I can't remember his first name now. He had a long-range forecast section there that was co-located with--I spent about eight months there learning the long-range forecasting techniques at the Weather Bureau. That was then combined with my statistical background and the work that George Wadsworth had done. We developed a method of making forecasts with statistical methods so I headed up the LRFD group, which was my function there in the Pentagon.

Rabson: When you say "long-range forecasting," what period of time are you talking about?

Bundgaard: We were talking a period of three to ten days, although the long-range forecasting by the statistical technique was three days, 72 hours, and up to a trial period of six days. But the other units there were going out from two to ten days, and Joe George, who came from Eastern Airlines, headed up the four units. And twice a week the four units would present their long-range forecasts in a room called the "scramble room." And they would put their forecasts on the wall with time running horizontally, and they would put the four different units in a row among each of them. Joe George's function was to try and go through that and make a scrambled long-range forecast from the four different forecasts.

Rabson: Sounds like kind of a prelude to what you did in Normandy.

Didn't Irving Krick make 30-day forecasts?

Bundgaard: I think he did, and I'm a little hesitant to talk about that because I'm not completely familiar with those forecasting programs. There was a group in the Weather Bureau at that time headed by a person from Caltech named Elliott and he was a close colleague of Krick. There were actually three long-range forecast units in the Weather Bureau. There was the one that Mitchell had that I've already mentioned that I worked with, and there was the one that Elliott had. I think 30-day forecasts were being made by Bob Elliott in collaboration with Irv Krick in the Weather Bureau. The third group (I can't think of his name now, the famous long-range forecaster who died five or six years ago). He had the main group.

So there were three long-range forecasting units at the Weather Bureau--this was over at 24th Street and M. Bob Elliott's group, Mitchell's group and this other group.

Rabson: When we talked before, you said that Krick was a good friend of Hap Arnold's, General Hap Arnold, and that Krick went to Europe in 1943 . You mentioned that he met with Commander Spotts of the Eighth Air Force. What transpired?

Bundgaard: These trips that were made by Irv Krick were under the personal request of Hap Arnold, who was the commander at that time. They had previous acquaintance from California. These trips were not done with the blessing of Don Yates. They really created quite a bit of conflict. This conflict is discussed pretty much at length in an interview that Don Yates did...what happened, I think, was that Irv Krick made two visits to Europe in the summer of 1943 and the fall of 1943, and he met with the people who were beginning the planning for Operation Overlord. He also met with Carl Spotts, who at that time I think was the commander of the Eighth Air Force. This was before SHAEF and ?USSTAFE were formed. I think he had whetted the appetite of Carl Spotts for long-range forecasting, better forecasting. So Spotts got back in touch with Hap Arnold and encouraged Hap Arnold to set up a Weather Central for the American military activities in Europe. It was under this kind of pressure by way of Irv Krick to Hap Arnold that got Don Yates involved, who was then the Director of Weather in the Pentagon.

Holzman: Where did Yates come up and get his meteorological background? Was it UCLA or Caltech?

Bundgaard: Yates was also a graduate of Caltech. I think he was probably in the class of 1934, the second class at Caltech. So he had the training that came out from the staff at Caltech.

Rabson: Then you said that Don Yates basically took the responsibility for that Weather Central in Europe, is that right?

Bundgaard: Yes. There was a great deal of confrontation that took place after Irv Krick got back from his late October visit to England, and I think Don Yates went down to Hap Arnold and complained about the direct access Irv Krick had established with Hap Arnold and what had happened was that Irv Krick was a lieutenant commander in the Navy and Hap Arnold wanted him in the Army Air Corps, so he had him transferred from the Navy--I think he came in as a major. He was working directly in Hap Arnold's office. Don Yates made an ultimatum to Hap Arnold: either Irv Krick worked for Don Yates, or he would not be allowed to do work, and I think finally Hap Arnold agreed with Yates that he would put Irv Krick under Don Yates.

Holzman: Where did you and Ben Holzman--how were you involved with these people at this time?

Bundgaard: Ben Holzman was in the Directorate of Weather, too, in the Weather Forecast Central there, and he was working with Joe George in a scramble room. I think he had come over from the Weather Bureau where he had been director of the Weather Forecast Office, and he was mostly working with the short-range weather forecast.

Rabson: Just one more question about working at the Pentagon. What kinds of techniques did you use to actually do the forecasting? Were you using equations, were you using any kind of mechanical assistance--calculating-type machinery or anything like that?

Bundgaard: Our technique was a "regression technique." We were doing auto-correlations with weather observations at any single station, and then cross-correlations with adjacent stations. It was auto-regression, where we would develop equation predictions based on auto-regressions and cross-regressions. So we were using historical data and developing relationships like that.

Then we did our computations with desk calculators, and we had two types of desk calculators which were very common in those days. Frieden was the one we primarily used, so we spent hours and hours punching keys. We also had a Monroe calculator. The Monroe calculator was hand-operated, with a lever, and the Friedens were electrical. That was a very slow process, developing regression coefficients.

A lot of that work was done up at MIT, at the computer lab there. I can't remember the name of the man who was head of the computer lab there, who George Wadsworth worked for. It was a very well-known name... We made a number of trips from Washington, D.C., up to MIT. I did, in connection with the LRFD program.

Rabson: During this time, did you ever have any dealings with C. G. Rossby?

Bundgaard: No, I didn't, not during this time. My first contact with Professor Rossby was in the summer of 1950. I spent that summer at Oxford, in England, and Rossby was there also. It was in connection with the centenary celebrations for the Royal Meteorological Society. I think I was there either three weeks or six weeks with Rossby at that time. When I was in Norway I became acquainted with him at that time, and it was not until later, in the early 50's, that I visited him at the University of Chicago.

Rabson: So you were at the Pentagon Weather Central and at some point you and Ben Holzman and Krick flew over to southern England. Can you tell us a date and then describe what you did then?

Bundgaard: The trip from Washington, D.C., to England was a hurried-up trip and it was under pressure from Carl Spotts to get our weather service there for the new organization that was being set up which was called the United States Strategic Air Forces in Europe--USSTAFE, which he was going to head up and this was going to combine the Eighth Air Force and the Ninth Air Force and the Thirteenth Air Force into a single operational unit. So it was a very quick effort that was made. This took place at the end of December and early January of 1943 and 1944.

I think there were six or eight of us and we all flew over together in the same airplane. I think Don Yates had gone a day or so ahead of time. I flew with Ben Holzman, a fellow named William Wyatt, who had the LRFA program--that was the Krick long-range forecast unit. Rodney Jones, who was also LRFA. Then, I forget the names of the two people who had the LRFB and the LRFC. Anyway, we flew over as a group and we flew in a C-47 and we made three stops. We stopped in Newfoundland, Greenland, Iceland and then finally into Prestwick, Scotland. From there we took the train down to London.

When we first arrived in London, we stayed a few days in London because there was a bit of conflict between Don Yates' predecessor taking over the activity there. (I can't remember his predecessor's name.) So we had to lay low for about a week until they got that worked out. Then we went down to Bushey Park, where we set up our weather central.

Rabson: What was your understanding about the kind of work you were going to be doing in England? Did you imagine there was an invasion planned?

Bundgaard: A good deal of work had already been done during the fall of 1943 in preparation for the invasion, but most of that had been done in England. You mentioned Rossby--he went over twice to help set that up, and by that time I think they began to get an organization going. We weren't quite sure when we first went over whether we'd be associated with the invasion effort, or whether it would be just an updating of the strategic bombing. It wasn't until after we got there, I think, in February that we began to realize that we would have the responsibility for the invasion, too.

Holzman: You mentioned in February about the strategic bombing. I have read in Thor's Legions that you played quite an important role in that and that the results were successful in rendering the *Luftwaffe* useless for the June event. Is that true?

Bundgaard: The really big event--I think it was called "Operation Argument"--took place in February, and there were five days of bombing that was done around Leipzig. And that was really the first big effort that this new Weather Central had a responsibility for. That was really successfully carried out by Ben Holzman, Irv Krick and Don Yates. That was a very decisive program. I think Fuller gives a very detailed account of "Operation Argument." I would probably have to refer to those notes to remember it, but I think that was probably the biggest success that Ben Holzman and Irv Krick engineered together. My part in that was only in getting the en route winds, the ballistic winds, the ballistic densities, but actually the choosing of the weather and the event, was primarily due to Ben Holzman with the help of Irv Krick. Probably the biggest success that I know of so far in weather forecasting.

Rabson: Were these daylight bombing runs, and was this the first time that had been done?

Bundgaard: These were daylight operations, yes. I think the "daylight operation" concept had already been started by the Eighth Air Force and Carl Spotts, as far back as in August, 1943, the concept of daylight operation but it had not been very successful, and there had been enormous losses. I think a lot of the strategic bombing was sort of delayed and postponed during the fall of 1943.

Rabson: You said you were down in Bushey Park and that group was called "Widewing." Who did you report to and what exactly were you in charge of?

Bundgaard: There was nobody to report to because they had replaced whatever staff that had been there before, and Don Yates sort of moved in. So I reported directly to Don Yates. We had three basic sections there: we had a surface section, an upper air section, and long-range forecast sections. The upper air section was under my leadership as well as the long-range forecast section called "LRFD." So I had kind of two functions there. In the beginning the upper air forecasting was my main function, but as we got closer to May and June, my activity with LRFD became the main function.

Rabson: What techniques did you use to forecast upper air? And when we're talking about upper air, are we talking about 10,000 feet and above or 15,000 feet?

Bundgaard: We're talking primarily about 10,000 and 20,000 feet. The most accessible map for upper air analysis at that time was at 10,000 feet. Actually, in Europe we were doing pressure analysis. We drew at 700 millibars and 500 millibars. And the Air Force in the United States was still doing constant-level analysis, which was 10,000 feet, 20,000 feet. But in preparation for going to Europe, we went into the new system of constant pressure analysis. Then, the main map level of 700 millibars, the [B-]17's and the Liberators would fly at higher altitude, which would be around 20-25,000 feet. The runs over the targets were often as high as 25,000 feet. So the main operational map was the 500 millibar map. But the amount of aerological data available at 500 millibars was not as great as at 700 millibars, so our basic map analysis was at 700 millibars. Our coverage would go from the Eastern Pacific across the United States and across the North Atlantic into Europe. The weather analysis over the United States and Eastern Pacific was sent to us from the Weather Central in the Pentagon and in Bushey Park we did the analysis over Europe and the Eastern Atlantic. But we ended up with a map coverage that would go from the Urals all the way to the Eastern Pacific. This is the first time there had been that much upper air analysis done. It was not global but-- the American service was the only one that had that extended coverage. The Air Ministry's analysis was just Europe to about 60 west longitude, the eastern half of the North Atlantic. So the American innovation was quite--this was important because if you remember in long-range forecasting, the long waves in the upper westerlies are very important, and the only way you could apprehend those was to extensive coverage such as we had from North America into Europe.

Rabson: How did you get data...?

Bundgaard: Of course, the crucial matter was aerological data, upper air data, and that was the ultimate limitation on the capability of the upper air analysis. We had aerological stations available to us from the British Isles and we had some in Iceland, which the Army Air Corps Weather Service set up, some in Greenland, and then we had those on the East Coast of the United States. In the British Isles--

END OF SIDE 1

Interview of Robert Bundgaard

SIDE 2

Bundgaard: The concept of tracking lightning by triangulation from three different radio receiving stations--you could locate the place where a lightning stroke took place. If you plot those, you often find that a line of lightning strokes will be associated with an advancing cold front or low pressure center. So we set up sferic triangular sensor sites in the British Isles and we could track sferics over most of the North Atlantic. It's a long wave radiation. So you could get sferic reports from out over the Atlantic, and you could get that almost immediately. So that was the way you could information about the synoptic weather patterns. That was a new technique that was introduced during World War II. It's being used today.

Rabson: Can you talk a bit about the 21st Weather Squadron?

Bundgaard: The 21st Weather Squadron was a mobile squadron and it was the first of its kind, the first ever in history where the weathermen that made up the squadron were also trained in combat. The 21st Weather Squadron was formed by Colonel Tom Moorman, who later became superintendent at the Air Force Academy and who just died here about a year ago. The Squadron was formed and trained at Bradley Field, in Hartford, Connecticut. It consisted of two types of vans, which were mobile and completely self-contained with power and instrumentation. The people that went with the van would make weather observations, both surface and upper air. They traveled with the combat units. That was the 21st Weather Squadron. They went from Bradley Field in the fall of 1943, and they were deployed with the Third Army and with the First Army with the invasion of Europe, and even a few days before the invasion, these weather people were dropped in ahead of time. And they also were used in the Meditteranean area. A companion with the 21st Weather Squadron was the 40th Mobile Communications Squadron. You need communication with weather observations to bring the information back. Both those squadrons were commanded by General Moorman.

General Moorman was also director of weather for the Ninth Air Force, which was one of the three air forces of USSTAF, the others being the Eighth and the Thirteenth. In addition, he was Omar Bradley's weather officer, and he also had river forecasting units and he did the sea swell forecasting for the Admiralty. And that all came out of the 21st Weather Squadron. It was located at Uxbridge, outside of London.

It was probably the most adventurous and most unusual of the weather services that was created and operated during World War II. A number of their members died as combat weather people.

Rabson: You also mentioned getting weather data from Russia, from the Soviet Union.

Bundgaard: That was one of the activities that Don Yates set up. He went to Russia twice, once was in November, 1942, and he had to abandon his C-54 in Siberia. They were planning to fly back from Russia by way of the Aleutian Chain, and they got into Siberia and the weather got so cold they couldn't get the C-54 cranked up again, so they had to borrow a German aircraft and fly the rest of the way back. And that's the first C-54 donated to the USSR during World War II. It never came back.

But on the second trip to Russia, General Yates took with him a fellow named Louis Mundell, who is now a retired lieutenant-general living in Savannah, Georgia. And Mundell set up a system at a place called Poltava, which was in Georgia (?USSR), for gathering together the German (?Russian) weather observations and then transmitting them into England, to the Army Weather Service there.

One of the interesting things about the Russian weather observations at that time--they were made at solar times, like "8:00 solar." Remember, Russia is such a wide expanse, it covers 17 different time zones, from Japan to Europe. So if you plotted solar time observations, the time difference between the western part of the map and the eastern part of the map could be 17 hours. So that was kind of a complication in the use of the weather observations.

Anyway, Louis Mundell was responsible for setting up a system so that the Allies could get Russian weather data, observations.

Rabson: Sverre Petterssen was also the head of the upper air section at Dunstable. Was he more or less your contemporary?

Bundgaard: That's putting it very nicely. He was the man I would like to emulate, so he was sort of a father figure for me rather than a contemporary. I did visit him twice at Dunstable. I went from Bushey Park over to spend weekends with him to find out how the master did the work, so I could carry the products of his effort back to Bushey Park. And, what should I say about Sverre Petterssen? He was "Mr. Upper Air" along with Dr. Sutcliffe and most of the things I learned about upper air analysis came from either Sutcliffe or from Petterssen. We tried to apply the things that they were doing at Dunstable in our work there at Bushey Park.

Rabson: I have one other question before I turn the mike over to Mel. How did you understand at Widewing the minimum conditions for a successful D-Day invasion?

Bundgaard: You know, this is a very good question because traditionally a military commander is not interested in marginal weather for a military operation. He wants to have the best possible weather and is very seldom interested in marginal weather for an operation. Yet the whole strategy and tactic of Overlord was just

the opposite of that. I think that was one of the main reasons the element of surprise could have been introduced into the D-Day operations, and it turned about knowing what the minimum conditions were.

First of all, the minimum was a very complex issue because what was the minimum for air operations would be quite different from what would be a minimum for sea operations. So one of the big problems that faced Group Captain Stagg and others was to come up with a coherent set of definitions of what would be the minimum that would be met. As you know, the invasion did occur after a postponement of 24 hours, and during a period when the weather was just marginally operational for the different operations. And it occurred between two storms during a period when the weather was only marginally operational for maybe 36 hours or so. But because of that, it probably contributed to the success of the operation because the German weather service thought it was absolutely inconceivable that a very sluggish invasion armada could be put together and put into operation into that 36-hour period between two successive storms. An operation that would take four or five days--and they couldn't conceive in any way that this could happen. So they forecast that this would be non-invasion weather. That doesn't mean that their forecasts were less accurate than ours, but they simply didn't think that anyone would have the courage to operate under marginal conditions.

Rabson: What kind of conditions did they need in the second day after the invasion? I mean, they still had to continue to bring men and matériel and supplies over.

Bundgaard: The invasion was made on a Tuesday and the next storm came in on a Thursday afternoon. So the following Wednesday was still operational. But then the sea and swell operations became bad on Thursday so that they couldn't make the landings then. So there was a hiatus of support that took place. But then the weather for the next seventeen days was very marginal and it turned out that they couldn't get in their munitions by sea and a lot of it had to be airdropped, brought in by aircraft after the invasion.

Holzman: Bob, during Operation Overlord, at the end of May, early June, there was a lot of pressure between Dunstable and Widewing for them to present data so that General Eisenhower could make his decision. Can you talk about the aspects of that process?

Bundgaard: The process of communication between the three weather services was by means of a scrambled telephone conference. And during that period starting around the 28th of May, these telephone conferences occurred several times a day and ended up just before the invasion being four times a day. The first invasion forecast was made on the 28th of May, and that was a long-range forecast, a six-day forecast. Neither Dunstable or the Admiralty had true capability for making the six-day forecast so that the forecast which Widewing issued on the 28th of May was tacitly accepted by the Admiralty and the Air Ministry without any criticism or

objection. And it wasn't until time got closer toward the 5th of [June]--the planned invasion date--that Widewing began to meet constructive criticism from the Air Ministry or Admiralty, because as you got closer, the length of the forecast decreased and they began to feel a bit more convinced that they had a capability to make sound judgement as to the forecast.

Holzman: On the data gathering for your forecasts from Widewing, can you comment on that and how you were putting it together in the time frame that you had?

Bundgaard: The data gathering was something that was pretty much commonly shared among the three weather centers. We all depended on the same sources of information. But the putting together synoptically and coming up with an accurate assessment of what the current situation was left a lot to be desired and there was a lot of disagreement among the three weather centers, even though they started from the same source data. And that was mainly due to the fact that there was such a hiatus of information over the area to the west of the British Isles, over the North Atlantic, and it left a lot for interpretation as to how to fill in the gaps with a synoptic analysis of what the current weather was. So a lot of the disagreement started initially among the three weather centrals as to what the current conditions were. But we all pretty much operated from the same data, and it was not having adequate data to the west of us that led [to] differences of opinion.

Holzman: Stagg was the liaison to Eisenhower, and how did Widewing influence his information, what he was going to tell Eisenhower?

Bundgaard: The way the conferences would work, each of the weather centrals would take turns in starting the conference and after the spokesman for, say, the Air Ministry had done his presentation, then the spokesman would come up from Widewing, the American group, and then the spokesman from the Admiralty would come up. And the spokesman from the Air Ministry was either Petterssen or Douglas--they would take turns. And the spokesman for the Admiralty was usually one of two persons: Hogben was one--and the spokesman from Widewing would be either Ben Holzman or Irv Krick. Early on, it would be also Don Yates. Then after they got together and had a discussion, the conference would be overseen by Stagg; he would listen to the discussions among the group and then he would try to come up with a consensus forecast of what he had heard being discussed by the three groups. So that the final responsibility fell upon Stagg and Don Yates to come up with what they thought they heard in the telephone conferences from the three groups.

Holzman: [The invasion] was changed from June 5th to June 6th. Was there consensus in Widewing that June 5th--was that the day that Widewing was forecasting and they changed later...?

Bundgaard: The answer is yes. The original forecast at Widewing made on the 28th of May for a favorable weather situation on the 5th of June. As the time approached the

5th of June, and the conditions began to deteriorate, Widewing was not willing to give up its forecast for a "go-ahead" on the 5th. Both the Admiralty and the Air Ministry became convinced as the time got closer to the 5th, that that should be a "no-go" situation for invasion. It became a dramatic showdown on Friday evening, I think would be the 2nd of June. Even at that point, Widewing was unwilling to give up on its go-ahead forecast. I think 2:30 on Saturday morning, the 2nd and 3rd of June, Irv Krick even made a special phone call over to Sverre Petterssen at the Air Ministry at Dunstable, to see if he couldn't persuade Sverre Petterssen to change his mind from a no-go forecast to a go forecast. And that was sort of the climatic moment of the whole event, and Sverre Petterssen was unwilling to change his mind. So at 5:30 that Saturday morning, under the pressure of Don Yates, who was down at Southwick at that time--he was no longer at Bushey Park--he was at Southwick where Eisenhower was located, I think Don Yates got on the phone and talked with Irv Krick and finally convinced Irv Krick and Ben Holzman to give in and accept the "no" forecast that the Admiralty and the Air Ministry were pushing so that by 5:30 on Saturday morning, all units agreed on a no forecast. But it came very reluctantly to Widewing. That's where all the tension took place between the three units.

Holzman: Can you expand on the interactions between yourself, Ben Holzman, Yates, Krick at Widewing when you were working on this data? Were you all together on it or did some of your or Ben's data or such make it that it was not certain for the 5th?

Bundgaard: I think as we got closer to Friday night, Saturday morning, it became evident that, at least to Ben and me, that the holdout was on the part of Krick. Already on Thursday, the LRFD group, which I was associated with, had convinced itself that the forecast for Monday would be a no-go forecast, so we were already deciding that--the LRFD part of Widewing was already in support of the Air Ministry's forecast. In fact, I had direct contact with Petterssen several times a day on my own, so I was discouraging and forecasting a non-invasion for the 5th. But I think there was so much of an ego trip involved for Irv Krick and the LRFA people, based upon his early forecast from the 28th of May, to hang onto that. And they kept looking at their historical weather maps trying to convince themselves that their forecast for the 5th of June would still be a good forecast. They actually had done three different analogue maps to support that so there was internal friction within Widewing over the 5th of May. And I think Ben Holzman was sort of in the middle and Krick was pushing for it and Yates, who was with Stagg down in Southwick, was in a very difficult position and it almost became a command decision by Yates to Krick to back off and that came at the last minute.

But if you read the dialogues of those telephone conferences, you can see how dramatic was the activity that took place in those telephone conferences.

Holzman: Was General Eisenhower aware when he was communicating with Stagg that this level of tension was evident?

Bundgaard: I think he was aware of it but it never showed up in the conferences as I understand it. There's one little side event that took place that indicates he must have known about it. I got this from Don Yates many years later. It turned out that sometime like on the end of [May], like the 30th of [May], Irv Krick went directly to Carl Spotts, who was the commander of USSTAF--the United States Strategic Air Forces in Europe. Carl Spotts was also at Bushey Park and Irv Krick went to Carl Spotts and asked Carl Spotts if he wouldn't intervene on behalf of Irv Krick with Eisenhower, and tell Eisenhower that [he] should rely on the Widewing forecast because Spotts had such a high regard for Irv Krick. And this came primarily from the success of the "Argument" week forecast that was done in February. Spotts did make a personal contact with Eisenhower sometime between the 30th of May and the 3rd of June to tell Eisenhower to go ahead with the Widewing version of the forecast. And that was almost an unforgivable thing for Krick to have done. He went around Yates and Stagg to go directly to Eisenhower. I think that caused a great deal of grief for both Stagg and Yates. That probably was the basis for which the final decision made by Yates and told Krick to lay off on early Saturday morning around 5:00 in the morning.

Holzman: So does that mean that by Widewing accepting the delay, that's what triggered the decision, then?

Bundgaard: I think so, because even afterwards, in the years that followed, at Camp Ord in 1984 where Krick was present, he still maintained at that time--and it's in the notes as published by the AMS--that Eisenhower could have gone ahead on the 5th of June with invasion--that the weather turned out to be as he had forecast as an acceptable invasion operation. It's amazing, but that's in the record in 1984. Even, as far as I can remember, until Krick passed away, he still believed that the invasion could have been weatherwise successful on the 5th. So he never gave up his belief that his forecast was right, even though everyone today would agree that having looked at the actual weather conditions on the 5th, it would have been an utter disaster had they made the invasion on the 5th.

Holzman: Did this aspect of Krick influence yourself and Ben? I presume that you and Ben were principally involved in providing the data and the analysis.

Bundgaard: I think at the time it certainly did affect the way we felt, particularly Ben and me. I don't recall that Ben Holzman ever showed any outward chagrin about it because he had such composure and he was a man that crisis never seemed to upset. He was such a decent person that he would never express any attack or vengeance upon anybody else. And it turned out as the months and weeks passed after that, that Ben Holzman and Irv Krick still had a friendly relationship, but professionally and--in terms of their meteorological background, there was a difference there but I don't think it affected their long-range relationship.

Holzman: That's very interesting. Can you talk about post-invasion, and your travels to Normandy?

Bundgaard: Everything came to a great relaxation after the 6th of June because prior to that, the tension at work had been horrendous. I think everybody was--well, first of all there were only three people, I think, who were briefed in on the details of the invasion--Ben Holzman, and Irv Krick and I were given the dates of the invasion, and I think we were given those dates either on the 12th of May or the 17th of May. So with that in mind, and the enormity of the task, we all took it very seriously and worked very hard. So after the 6th, there was a great deal of relaxation and just recovering from hours of lack of sleep and so on. So I don't have a very close recollection of what happened between the 6th and the next weather event was on the, I think it was the 19th of June, when that weather storm broke up those landing barges, you remember, on Normandy. And I think that one reason we may have missed that forecast is that we were in kind of a relaxed state and weren't really giving our full effort toward looking at that weather situation that showed up on the 19th of June.

Holzman: Did you set up a weather station in Normandy after that?

Bundgaard: I think a few weeks after the invasion an USSTAF advance team was set up to go to Normandy, to support operations closer and a small group of us became "Widewing Advance," and it involved Don Yates and Ben Holzman and about three other fellows and myself. We went to a place on the Cherbourg Peninsula called "Grande-Ville-sur-la-Mer," and we set up a weather operation there. It was partly in an old German barracks and partly in a French farmhouse. We were there until the "Breakout" of Normandy, which took place maybe nine weeks later.

Holzman: That's all I have for now.

END OF INTERVIEW

ROBERT BUNDGAARD INTERVIEW

Index