An Interview with

CHARLES CRITCHFIELD

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Charles Babbage Institute
The Center for the History of Information Processing
University of Minnesota, Minneapolis

Charles Critchfield Interview
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Abstract

The interview mainly concerns John von Neumann, who Critchfield knew through his thesis advisor, Edward Teller, and through his work at Aberdeen and Los Alamos. It describes von Neumann's work on shaped charges; his work at the Ballistics Research Laboratory in Aberdeen, Maryland and his interactions there with Robert Kent; and his consulting work at Los Alamos, especially on the implosion device.

CHARLES CRITCHFIELD INTERVIEW

DATE: 29 May 1987 INTERVIEWER: William Aspray

LOCATION: Los Alamos, NM

ASPRAY: This is an interview on the 29th of May, 1987 with Charles Critchfield in Los Alamos, New Mexico. Let me begin by asking you first how you came to know von Neumann and what continuing contacts you had with him.

CRITCHFIELD: Well, I first met Johnnie when I was a graduate student with Edward Teller, who is also Hungarian; and they were good friends.

ASPRAY: You were in Washington?

CRITCHFIELD: I was in Washington D.C. and von Neumann was in Princeton. But he often came to Washington and when he did always came to the Teller's house, and I was there quite often. So I got to know him then, more or less socially, because we would be at parties. Of course, we would talk physics and mathematics too. After my Ph.D I went to Princeton on a National Research Council Fellowship with Wigner, who is also Hungarian and a good friend of von Neumann. I was a member of the institute at that time too, part time.

ASPRAY: What year was this?

CRITCHFIELD: That would be 1940-41. There again, it was mostly social. But at that time von Neumann was getting interested in scientific work at the Aberdeen Proving Ground through Bob Kent. He became especially interested in shaped charges -- high explosives, which require quite a lot of machining for precision geometries designed especially to pierce tank armor.

ASPRAY: I see. So the shape of this charge has some bearing on how well it pierces -- is that right?

CRITCHFIELD: That's right. By making a well defined cone, the convergence of the high explosive materials after the detonation produces a very penetrating jet, which goes through a lot of armor. He was interested in that and the physics of it -- the mathematics and physics of it.

ASPRAY: This was done for BRL?

CRITCHFIELD: This was done for BRL. He, and Wigner, and Veblen and I used to go down to Aberdeen and talk to Kent. I got interested in shock waves at that time also, but I didn't come into war work until 1942 when I went to the Geophysical Laboratory to work on high velocity projectiles. Los Alamos started at that time in late 1942, and they decided to come here in New Mexico. Oppenheimer and Teller came to see me and to see whether I could come and work on the assembly of the gadget, because Oppenheimer thought we would have to use two pieces, one of which was shielded by boron coating, which is very similar to what I was doing with high velocity projectiles. I was shooting small diameter projectiles from large guns by putting a plastic coating around which is called a sabot. That's the sort of thing that Robert Oppenheimer thought would be needed for the assembly of the gadget, the gun. Although my training was in mathematical physics, I came here to do that. The plan was to have a fairly low velocity gun for the uranium and high velocity for the plutonium. When we first got here in April, and I actually came here full time in June, Neddermeyer was here and he was interested in an idea which, incidentally had come up before at Berkeley, especially with Richard Tolman. Not imploding, as now defined, but assembling the material by high explosives, blowing them together, which is rather a far-fetched idea, but which, of course, is similar to the shaped charge idea.

ASPRAY: To create a heavy density...?

CRITCHFIELD: Well, the density part came in a little bit later. But, of course, that's a part, that's a big factor.

ASPRAY: What was the interest in blowing it together originally?

CRITCHFIELD: Just to do it rapidly. Of course it raised questions like, "How are you going to set it off on time?" and that sort of thing. But, anyhow, Neddermeyer took up this idea. Of course, Neddermeyer was also from Cal Tech. I talked to Seth in the last year or so, and he can't remember talking to Dick Tolman about this. But anyhow, here, he backed the idea, which of course was not in the main stream at that time. Oppenheimer and Teller and Bethe and so on did not pay much attention to it, but he continued to implode, especially cylinders. That autumn, as I recall (now Lillian [Hoddeson] can check these dates because I get mixed up sometimes), but I think it was in October of 1943, Johnnie came here and heard about Seth's work. With his own interest in shaped charges, he gave a nice talk in which he convinced everybody that we really should be looking at this. In other words, it was feasible to actually machine plastic explosives to the point where you could use it for an assembly. But I still think that the other questions remained; how are you going to set it off on time? It was at that time that the laboratory took a serious interest in the implosion device. So I always credit Johnnie with being the catalyst, which brought that about. It was not until the next April, as I recall, that it became clear that we couldn't use the gun with the plutonium. So the implosion became a really critical development in Los Alamos work.

ASPRAY: But in that intervening time, there had already been an increase in the amount of research, or interest in...

CRITCHFIELD: Yes, this group was taken seriously. Before that it wasn't, you see. He and I both were actually working for Captain Parsons.

ASPRAY: Neddermeyer and you?

CRITCHFIELD: Yes, and also Ed McMillan. Parsons was primarily interested in the gun. He was a Naval Ordnance man and was actually an Annapolis graduate a career navy officer. But he was primarily interested in the gun assembly. After that Seth's group was increased and eventually Kistiakowski was brought in. During this time von Neumann was extremely interested in how we were getting along. He came here, I forget how frequently, but enough to give us talks on shock waves and hydrodynamics and in general, very nice lectures of his.

ASPRAY: Were they of real significance to training the group that was working on a day-to-day basis on these problems?

CRITCHFIELD: Well, I would say, so far as the general appreciation of physics is concerned, and the regions of pressure, and temperature and so on that we had to deal with at molecular speeds, it certainly made a lot clearer why they existed, and what the limits were and that sort of thing. It certainly helped very much. Then, as you know, that grew to be a major part of the laboratory's effort. By August 1944, there was a reorganization of the laboratory, which split the work up. The explosive work was separated from what we called the gadget work, and initiator work, and things of that sort. So I would say that he was very instrumental in initiating serious attention to the idea, and he was instrumental in helping us do our work.

ASPRAY: Let me come back to this question of the relationship between von Neumann's past work at BRL and this work here. How do the problems compare? Are they similar enough so that would provide the experience or insight for him to recognize the value of Neddermeyer's approach?

CRITCHFIELD: Well, sure. They are so much related. You see, it's a new realm in explosives, so to speak. Explosives had never been subject to any high quality control. I mean, you put it in a bomb and you blow things up. Here they had to be homogeneous to a much higher degree than ever thought of before. They actually had to be machined. So the inspection requirements were much higher. Of course, eventually we had to get into lenses, which is a new development along these fields, and which of course fascinated von Neumann very much... It was done with gradations in density of the explosives, and again with very high control over the geometry. Because the implosion idea had just been born, and it couldn't possibly be in the state where we are now; it was very different. But our early results, say in the field where we made implosions and took pictures and tried to get an idea of what was going on, looked terrible. It was a real mess in there as you might expect. If you blow something together, it's going to be a mess. That is why, eventually, we were under pressure to get something done before we had to invade Japan. We went to the Christie gadget, which solved a lot of problems without the uncertainties we faced with the more sophisticated kind of design. But certainly when you have people with the kind of confidence that von Neumann

had -- and we had other people here that kept us encouraged, like Niels Bohr, whose physical insight on things was a great help. Rabi, and Tolman, and Charlie Lauritsen -- older men with experience; well, Johnnie was one of those. You just had confidence in what he said. Actually one of the big things about what we did here was that, unless you had that confidence, you would never know because what you were saying is that you could take something the size of a golfball and get 20,000 tons of TNT out of it [laugh]. I mean, that's the amount of material that's involved. Of course, with the gadget it is bigger than that.

ASPRAY: Who originated the idea of lenses?

CRITCHFIELD: Well, a number of people take credit for that. Tuck claims that they thought about it in the British mission. He was a British contributor to our work here. He says that he had the idea, even then, before he came to the states. My own recollection is that before the British mission came, that Hugh Bradner, who worked with Seth, had the idea that he would shape the detonation wave. But then I didn't have any critical influence in this. I just remember his talking about it.

ASPRAY: I remember there being a patent held by von Neumann and Neddermeyer and the British fellow.

CRITCHFIELD: Tuck?

ASPRAY: Tuck, yes.

CRITCHFIELD: Well, I think that when it comes to real serious work, we'd have to consider bringing in both Johnnie and Jim Tuck. Neddermeyer's interest in this thing was not that serious, and that's why he was replaced later. His original idea was to take the material and blow it, just with enough explosives to bring it together and hold it together in a critical state. When it soon became clear that if you used more explosives you'd compress it, he actually resisted that. He said, "It'll blow apart." That was one of the reasons that he was removed from his leadership of that group, and it was given to Kistiakowski, because he was stubborn about it. He didn't want to push it. Just like Parsons

before him didn't want to push the implosion, he didn't want to push the implosions to the extent to which it could be taken. Of course, it's a much bigger challenge to compress something because the symmetry has to be so much higher. Seth's idea was safe; you just blow it together and you've got it. As it turned out, as you know, the Christie gadget already had it assembled. You just compressed it to make it go (laugh).

ASPRAY: Was there a substantial interaction between von Neumann and Kistiakowski when he came?

CRITCHFIELD: Well, whenever Johnnie was here there was. I don't know about elsewhere. I don't know whether Johnnie was interested in the work at Bruceton, especially. You'd have to look to other people for that. That was the military's laboratory for explosives, you know, near Cumberland some place. I don't know his connection to that. He must have had some through BRL.

ASPRAY: I'd like to come back to this earlier period at Aberdeen and ask you a couple more questions about that. Garrett Birkhoff has told me that it was Bob Kent who really got von Neumann interested in these questions of shock waves and fluid dynamics, and who taught him all the very practical things that were known from earlier on, and that once von Neumann learned these fundamentals then he took off on his own and developed a lot of the theoretical work. Herman Goldstine has told me that he doesn't believe that. He thought von Neumann already knew a lot of this material before he came to Aberdeen and that he was brought in because he was knowledgeable about this subject. Can you shed any light on this?

CRITCHFIELD: I never talked to Johnnie about that background. It would be my guess that Johnnie knew the Rankine-Huginiot theory and that sort of thing. But you know, in just a casual way, Kent got him interested in the importance of it. That would be my interpretation, so they're both right in a sense.

ASPRAY: Can you tell me something about Bob Kent's background and his interaction with von Neumann?

CRITCHFIELD: I don't know where they met. I know that Kent was keenly aware of the need for help, and he

somehow contacted either Veblen at Princeton or von Neumann to see if anybody was willing. And they willingly came down there.

ASPRAY: I think it was Veblen, because during the first World War Veblen had been a consultant of the labs and was very interested in seeing things go on.

CRITCHFIELD: That makes sense. And, of course, these men were keenly aware of what was going on in Europe, and were anxious to help. That's why Wigner and I went down. So when I was at Princeton, he and I used to go to Aberdeen to talk to Bob and to decide what are the problems. Later when I went into war work in Washington, I went to Aberdeen to get my high velocity projectiles photographed by Harold Edgerton, who was starting his work at that time. So we always had a lot of friendly relationships.

ASPRAY: Was Kent mathematically knowledgeable?

CRITCHFIELD: Yes, I would say he was quite capable.

ASPRAY: I understand there was a close social fondness between Kent and von Neumann. Did you see that?

CRITCHFIELD: Well, I thought they were quite cordially related. I don't know anything more personal than that.

ASPRAY: I see.

END OF INTERVIEW