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Heisenberg in Copenhagen

Paul Lawrence Rose, reply by Thomas Powers

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To the Editors:

Thomas Powers's rhapsody on Michael Frayn's play *Copenhagen* [NYR, May 25] perpetuates a number of factual errors deriving both from the play and from the reviewer's own book.

- ① Powers and Frayn assert Heisenberg never calculated the critical mass of a U235 nuclear bomb. In fact, as my book *Heisenberg and the Nazi Atomic Bomb Project* (University of California Press, 1998) proves, Heisenberg had made such a calculation in early 1940 using the statistical technique known as the random walk and concluded that the critical mass was of the order of tons of U235. He did not simply dream this up as Frayn's argument insists, but *calculated* it using nuclear data. The calculation is rehearsed no less than three times in the transcripts of the taped conversations between Heisenberg and other German physicists interned at Farm Hall in England in August 1945. It was this gross overestimate of the amount of U235 required for a bomb that prevented Heisenberg from driving ahead at full speed with the uranium bomb project.
- ② Heisenberg pursued work on other nuclear weapon possibilities until 1942, rather than being the innocent that he is portrayed by both Powers and Frayn. A secret German report of early 1942 describes an exploding "reactor-bomb" on which Heisenberg's assistant had worked in 1940. He seems to have discussed this with Bohr at Copenhagen in September 1941, to judge by the diagram of a reactor-bomb which Bohr provided to the scientists at Los Alamos in December 1943.
- ③ Heisenberg was never in danger of his life from the Gestapo for talking to Bohr at Copenhagen, as Powers and Frayn fantasize. The mission was an intelligence foray, arranged by Heisenberg's confidant Carl-Friedrich von Weizsäcker (with the approval of the latter's father, Ernst von Weizsäcker, the German State-Secretary for Foreign Affairs, later convicted as a war criminal at Nuremberg) with the purpose of ascertaining how far the Allied project had progressed and establishing whether a nuclear weapon was scientifically feasible. That such a fervent German nationalist as Heisenberg, who in 1941 and after preached publicly and privately the virtues of a German conquest of Europe, would say anything treasonous to Bohr is hardly credible. (Heisenberg, as far as I am aware, could never bring himself, even after the war, to speak in favor of the July Plot against Hitler.)
- ④ Heisenberg discussed at Nazi meetings in February and June 1942 the possibility of a plutonium bomb. He understood that plutonium would be produced by uranium reactors, but greatly overestimated the time and scale of operation required to produce sufficient plutonium for a bomb. He also failed to have his experimental reactors reach criticality (Fermi had achieved this by December 1942). The inability of Heisenberg to achieve a plutonium bomb was due to incompetence more than anything else and it is ridiculous to bring in considerations of morality here.
- ⑤ Powers and Frayn make much of the moral question of whether scientists should exploit nuclear power. But this is not the moral question that Heisenberg and other German scientists faced in 1939-1945. Their moral dilemma was whether they should build a German bomb which would advantage the Nazi state. I have analyzed their responses at length to this question in my book and believe that my conclusions have been vindicated by the recent admission of Carl-Friedrich von Weizsäcker that he was indeed enthusiastically working on a bomb for Hitler in 1939-1940. That he and Heisenberg were able to move the atomic bomb project from an urgent front burner to a leisurely back burner by 1942 was not due to any influx of moral scruples, but simply because Heisenberg had miscalculated, first the mass of a U235 bomb, and second, the time and scale required for the production of plutonium.

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Thomas Powers replies:

Before addressing the specific objections of Professor Rose, I would like to remind readers, first, of why the question of Heisenberg's motives remains open, and second, of certain evidence casting light on his thinking which neither Professor Rose nor other critics of Heisenberg have yet been willing to address.

When the war came to an end the American ALSOS Mission, tracking down German scientists (Heisenberg among them) and the reports of German uranium research, concluded that no serious effort had been made—certainly nothing that even approached the stage of actual development of an atomic bomb—and that the early feasibility studies ended in June 1942, when Heisenberg and others told Albert Speer that a bomb was too big, too expensive, and too uncertain for Germany to undertake in wartime. Explaining why so little was achieved despite the many advantages enjoyed by Germany at the outbreak of war in 1939 is what brings us to the question of Heisenberg's motives as the chief of theoretical efforts. What he said on his own behalf, very tentatively at the end of the war, was that he and some of his colleagues were not very eager to build a bomb for Hitler. The response was so angry that he soon quit talking about it, and that anger, as Professor Rose's book makes abundantly clear, is still lively and strong.

Heisenberg's own testimony does not appear in a vacuum. Other people also claimed that German scientists resisted pressures to push work forward on a bomb, and some of their claims, made both before and during the war, disappeared into intelligence and other official files where I and other historians found them. I'll cite three.

—In the summer of 1939 Paul Rosbaud, a German spying for the British, told the scientist R.S. Hutton in London that a German bomb program was hindered because "German physicists...refused to cooperate."

—In April 1941 a German Jewish physicist, Fritz Reiche, arrived in the United States bearing a message from Heisenberg's colleague and friend Fritz Houtermans which was relayed to American officials in the following handwritten note: "a reliable colleague [Houtermans] who is working at a technical research laboratory asked him [Reiche] to let us know that a large number of German physicists are working intensively on the problem of the uranium bomb under the direction of Heisenberg, that Heisenberg himself tries to delay the work as much as possible, fearing the catastrophic results of a success."

—In May 1943 the German spy Erwin Respondek passed a report to Sam Woods, an American consular official in Zurich, that "the Kaiser Wilhelm group [where Heisenberg was chief of theoretical work in Berlin] purposely raised 'difficulties' to slow down work on the project."

These claims (all abundantly footnoted in my book *Heisenberg's War: The Secret History of the German Bomb* [Da Capo, 2000], for those who would like to pursue the matter) do not necessarily answer questions about Heisenberg's wartime role once and for all—Rosbaud, Houtermans, and Respondek might all have been led down the garden path. But absent strong evidence that is the case, they are all clearly relevant matters which no honest historian can dismiss and ignore. I would take Professor Rose's claims about Heisenberg more seriously if he would seriously address, for starters, the April 1941 Reiche report, beginning with a concession that it was actually delivered, unless he is prepared to refute the evidence.

The points in Professor Rose's letter all open doors into interesting but complex disputes, some of which, fundamentally matters of interpretation and opinion, may never be resolved. Three of Professor Rose's points address questions of fact.

① —Frayn believes Heisenberg never calculated critical mass for a uranium bomb; I think he did, but made no point of my differing view in my review of his play. I think Heisenberg did the calculation early in the war and came up with roughly the right number—a matter of kilograms. Manfred von Ardenne, a German physicist working in Berlin in 1940, says he was told this by Otto Hahn, who in effect confirmed the report at Farm Hall in Britain in August 1945, where ten detained German scientists were bugged by British intelligence. There Hahn questioned Heisenberg's remark that "tons" of U-235 were needed for a bomb: "But tell me why you used to tell me that one needed 50 kilograms of 235 in order to do anything. Now you say one needs two tons." In June 1942 Heisenberg answered a question about the size of the fissionable core of a bomb by holding his hands to suggest something the size of a football or pineapple, which would have been roughly right.

The "random walk" estimate referred to by Professor Rose was the theory which Heisenberg told his fellow scientists at Farm Hall, some of whom really had wanted to build a bomb, was the reason for his (radically too big) estimate of tons. It represents a shorthand way of estimating critical mass—the amount of fissionable material required for a runaway chain reaction, which is another way of saying "explosion." It goes roughly like this (keeping in mind that I

am not a bomb scientist): each fission releases enough energy to move a speck of dust, and at the same time triggers two subsequent fissions. In order to move trillions of specks, and thereby raze a city, you need eighty generations of fission—each twice as large as the preceding generation. “Mean free path” refers to the average distance each released neutron must travel before striking another atom of U-235 and producing another fission. Take that distance, multiply by eighty, and you get the diameter of a sphere of U-235 required for a bomb. As calculated by Heisenberg at Farm Hall in August 1945, the diameter was on the order of a meter, suggesting a bomb would require several tons of U-235. (The real figure was actually closer to ten kilograms.)

But this approach is flawed by a basic error: neutrons do not have to travel always outward in a straight line to reach another atom—they can go in any direction, meaning that the sphere in fact requires only to be on the order of a few inches in diameter. In addition, escaping neutrons can be deflected back into the sphere by a “tamper”—a layer of highly polished, heavy metal encasing the U-235, the use of which Heisenberg understood. The significance of the “error” is that U-235 is difficult to make, and tons of it would have been beyond the wartime capacity of anyone, Americans included. So we are left with something of a paradox: Heisenberg in 1940 told Hahn only a few kilograms of U-235 were necessary for a bomb, and in 1942 he suggested a bomb core would be the size of a pineapple; but later in the war, apparently using “random walk” calculations, he told officials who wanted to build a bomb that tons would be required. Professor Rose thinks these varying estimates represent “scientific mistakes.” I think not.

2 —Heisenberg drew a picture for Bohr which the Dane mistakenly thought represented a bomb, but which scientists at Los Alamos at the end of 1943 immediately identified as a reactor. I do not know of any evidence that Heisenberg ever discussed anything called a “reactor-bomb” with Bohr or anybody else. Heisenberg said he told Bohr that atomic bombs were feasible and that Germany had a program to build one. The confusion that persists about this conversation centers mainly on what made Bohr so angry.

3 —Professor Rose says Heisenberg’s trip to Copenhagen was “an intelligence foray.” That implies the trip was both authorized by and reported to an intelligence organization. I very much doubt that Professor Rose can present evidence of either.

This controversy can be mind-numbingly complex, so I think it worthwhile to mention what I think is at stake and why the argument matters. The conventional history of nuclear weapons says that in no case have scientists seriously, much less successfully, resisted official requests to develop atomic bombs. The implication is obvious: if no one has found an effective way to refuse, then those who went ahead have nothing to explain or apologize for. But I think that in fact Heisenberg did find a way to say no—by stressing the expense and the difficulty—that made a difference, thereby demonstrating that scientists everywhere, then and since, have the power to decide for themselves. Heisenberg said the explanation for the tepid enthusiasm of the German scientists was to be found in their “psychological situation,” by which he meant that the Germans were being asked to build a bomb for Hitler, while the Allies were doing so to ensure Hitler’s defeat. This is generous but does not really exhaust the question. Why Professor Rose takes this matter seriously I do not know, but I would like to know and hope he will interpret this as an invitation to continue the discussion.