flatworm than to the brain of man and so hardly constitute a threat. If practical machines of this type become a reality we will have to take a much closer look at their implications than either Wiener or I have been able to do.

One final matter requires some clarification—a matter having to do with Wiener's concluding remarks to the effect that "We must always exert the full strength of our imagination to examine where the full use of our new modalities may lead us." This certainly makes good sense if we assume that Wiener means for us to include the full use of our intelligence as well as of our imagination. However, coming as it did at the end of an article which raised the spectre of man's domination by a "learning machine," this statement casts an unwarranted shadow over the learning machine and, specifically, over the modern digital computer. I would be remiss were I to close without setting the record straight in this regard.

First a word about the capabilities of the digital computer. Although I have maintained that "nothing comes out that has not gone in," this does not mean that the output does not possess value over and beyond the value to us of the input data. The utility of the computer resides in the speed and accuracy with which the computer provides the desired transformations of the input data from a form which man may not be able to use directly to one which is of direct utility. In principle, a man with a pencil and a piece of paper could always arrive at the same result. In practice, it might take so long to perform the calculation that the answer would no longer be of value, and, indeed, the answer might never be obtained because of man's faculty for making mistakes. Because of the very large disparity in speeds (of the order of 100,000 to 1), on a computer we can complete calculations which are of immense economic value with great precision and with a reliability which inspires confidence, and all this in time intervals which conform to the demands of real-life situations. The magnitude of the tasks and the speed with which they are performed are truly breath-taking, and they do tend to impress the casual observer as being a form of magic, particularly when he is unacquainted with the many, many hours of human thought which have gone into both the design of the machine and, more particularly, into the writing of the program which specifies the machine's detailed behavior.

Most uses of the computer can be explained in terms of simulation. When one computes the breaking strength of an airplane wing under conditions of turbulence, one is, in effect, simulating the behavior of an actual airplane wing which is subjected to unusual stresses, all this without danger to a human pilot, and, indeed, without ever having to build the airplane in the first place. The checker-playing program on the I.B.M. 704, to which Wiener referred, actually simulates a human checker player, and the machine learns by accumulating data from its playing experience and by using some of the logical processes which might be employed by a person under similar circumstances. The specific logical processes used are, of course, those which were specified in advance by the human programmer. In these, and in many other situations, the great speed of the computer enables us to test the outcome resulting from a variety of choices of initial actions and so to choose the course with the highest payoff before the march of human events forces us to take some inadequately considered action. This ability to look into the future, as it were, by simulation on a computer is already being widely used, and as time goes on it is sure to find application in more and more aspects of our daily lives.

Finally, as to the portents for good or evil which are contained in the use of this truly remarkable machine—most, if not all, of man's inventions are instrumentalities which may be employed by both saints and sinners. One can make a case, as one of my associates has jokingly done, for the thesis that the typewriter is an invention of the devil, since its use in the nations' war offices has made wars more horrible, and because it has enslaved the flower of our young womanhood. On the whole, however, most of us concede that the typewriter, as a labor-saving device, has been a boon, not a curse. The digital computer is something more than merely another labor-saving device, since it augments man's brain rather than his brawn, and since it allows him to look into the future. If we believe, as most scientists do, that it is to our advantage to increase the rate at which we can acquire knowledge, then we can hardly do otherwise than to assert that the modern digital computer is a modality whose value is overwhelmingly on the side of the good. I rest my case with this assertion.

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31 May 1960

Spring Peak of Strontium-90 Fallout

Abstract. An increasing trend of Sr^{90} concentration in rain observed at Fayetteville, Ark., after November 1959, indicates that the seasonal and global movements of stratospheric air masses, such as described by Brewer (*1*) and Dobson (*2*), play an important role in causing the spring peaks of the Sr^{90} fallout.

To explain the vertical distributions of water vapor and ozone in the atmosphere, Brewer (*1*), in 1949, and Dobson (*2*), in 1956, proposed a model of global movement of the air masses. According to this model, there is a cold pool of air in the stratosphere over the winter pole during the late winter months, and it carries ozone-rich air to the lower levels in early spring. It was further suggested by Dobson that, if there is such a slow sinking of air in the middle latitudes from the stratosphere to the troposphere, it must be balanced elsewhere by a reverse current from the troposphere to the stratosphere.

Stewart *et al.* (*3*), in 1957, explained the spring peaks in the rate of stratospheric Sr^{90} fallout on the basis of the Brewer-Dobson model, and Burton *et al.* (*4*) reported that the Po^{210}/Pb^{210} ratios in the samples of air filter and rain can also be explained on the basis of the global circulation model of air masses. Kuroda (*5*) observed the 1958 spring peak of the stratospheric Sr^{90} fallout, and Fry *et al.* (*6*) pointed out the fact that the Sr^{89} concentrations in rain and snow remained fairly constant during the winter and spring months of 1958–59, despite the fact that this nuclide decays with a half-life of 51 days. They explained this as due to a marked increase in the rate of transfer of the fission products from the stratosphere to the troposphere in early spring months.

An alternate explanation for the spring peak of the rate of stratospheric fallout was proposed by Martell (*7*) in 1959, and this view was later sup-

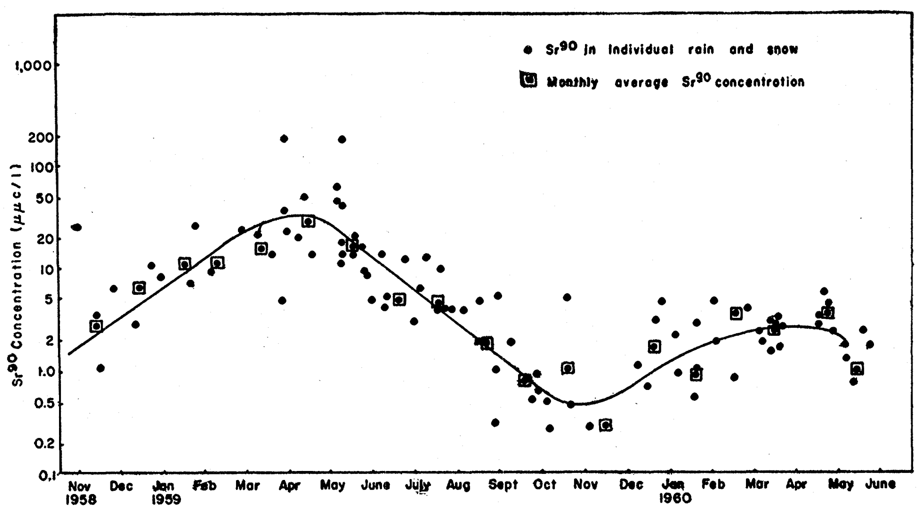

Fig. 1. Variation of the Sr^{90} concentration in rain and snow at Fayetteville, Ark.

ported by Libby (*8*). According to Martell, the clouds of stratospheric debris from middle-latitude and arctic U.S.S.R. detonations apparently reach the lower stratosphere after only limited diffusion and release substantially all of their contamination into a zone of restricted latitude during the first 6 months or so.

We have measured the Sr^{90} concentrations in individual samples of rain and snow collected at Fayetteville, Ark., during the period between November 1958 and May 1960, and the results are shown in Fig. 1. The monthly average Sr^{90} concentration in rain (C) was calculated from the equation.

$$\bar{C} = \Sigma F / \Sigma R,$$

where ΣF is the total amount of Sr^{90} (in micromicrocuries per square meter) transported by rain during the month period and ΣR is the total rainfall (in millimeters) during the same period. Our data show a marked seasonal variation of the Sr^{90} concentration in rain which follows a cyclic pattern with a maximum in the spring and a minimum in the fall, as would be expected from the global circulation model of air masses such as proposed by Brewer and Dobson. The cyclic pattern is similar to that of the seasonal variation of ozone in air reported by Paetzold (*9*).

The Sr^{89}/Sr^{90} ratios in the samples of rain and snow are plotted in Fig. 2, together with the data obtained by W. F. Libby at Washington, D.C., during the first 4 months of 1959. Fry (*10*) has recently estimated from the isotope ratio data that approximately 60 percent of the Sr^{90} fallout during the first half of 1959 originated from the fall 1958 U.S.S.R. test series. Figure 2 indicates that the fraction of the Sr^{90} which originated from the "older" debris has somewhat increased during the second half of 1959.

It is interesting to note that Feely (*11*) has recently reported that a mean stratospheric residence time of less than 18 months has to be assumed to explain the presence of only 1.0 megacurie of Sr^{90} in the stratosphere by mid-1958. Our data seem to be explained quite well by the assumption that whereas the transfer from the stratosphere occurred at a maximum rate in the spring months and at a minimum rate in the fall months, the over-all rate of the Sr^{90} transfer from the stratosphere during this period was roughly equivalent to an "apparent" stratospheric mean storage time of approximately 1 year or even less (*12*).

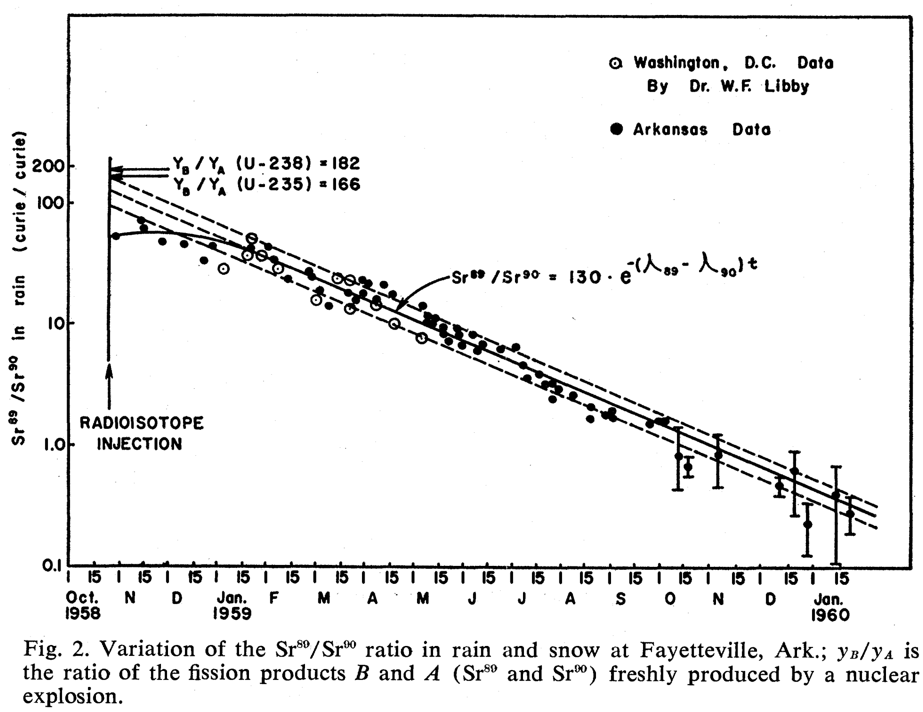

Fig. 2. Variation of the Sr^{89}/Sr^{90} ratio in rain and snow at Fayetteville, Ark.; y_B/y_A is the ratio of the fission products B and A (Sr^{89} and Sr^{90}) freshly produced by a nuclear explosion.

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