the magnet

Published for the employees and families of
LAWRENCE RADIATION LABORATORY
University of California
Berkeley • Livermore

July, 1967 Vol. 11, No. 7

'Electron-Positron' Linac To Be Built At Livermore Lab

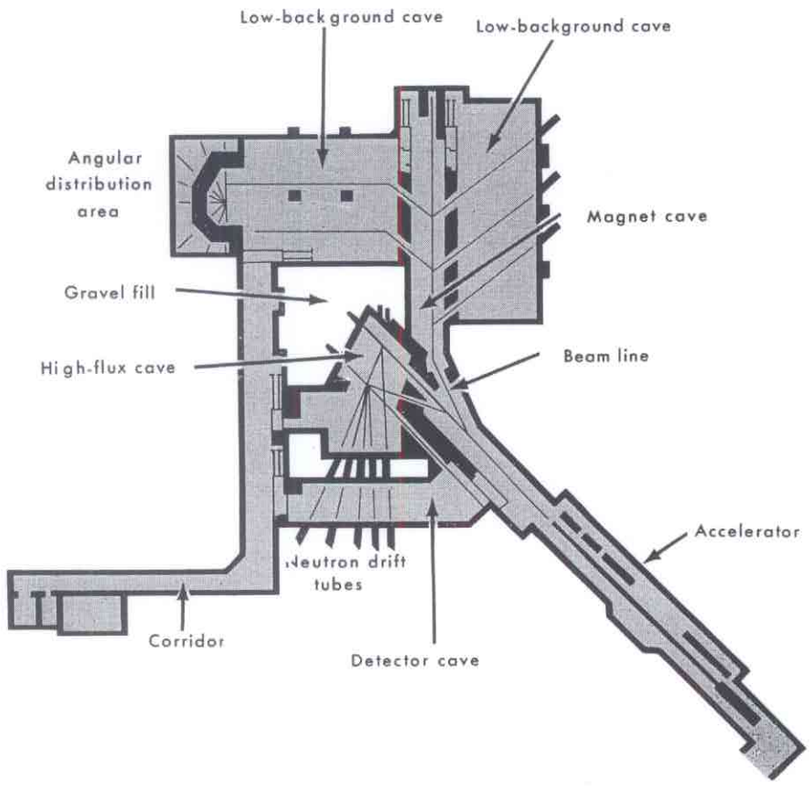
A major new accelerator with unique capabilities for studies of electromagnetic interactions, neutron physics, and applied reactor technology will be operating at LRL's Livermore Laboratory by mid-1969.

The AEC recently announced the allocation of $4.1 million to build and house the new 100 MeV "electron-positron" linear accelerator. The machine will be similar in principle to the 25 MeV Linac which has been in use at Livermore for the past seven years, but will have greatly extended capabilities and power.

The accelerator will be a Laboratory-wide research facility, operated by Livermore's E (Experimental Physics) Division. Physicist in charge of procurement of the new facility is Dr. Stanley Fultz, who has headed the present 25 MeV accelerator group.

The accelerator derives its name — "electron-positron Linac"—from its ingenious use of annihilations between electrons and positrons (which are each other's antiparticles) to produce beams

Continued on Page 4



UNDERGROUND AREA of new Livermore Linac will contain the klystron-powered accelerator (r.), neutron drift tubes, and several experimental caves.

LRL Scientist's Persuasive Theory:

NEW CLUES IN J.F.K. ASSASSINATION PHOTOS

Working with a pair of draftsman's calipers and an old copy of *Life* magazine, LRL physicist Luis Alvarez has made a discovery which appears to be one of the most important pieces of technical evidence ever brought to light in connection with the assassination of President John F. Kennedy.

Alvarez' discovery, backed by independent evidence obtained in a carefully-controlled series of empirical tests, was featured in the recent CBS television four-part special report on the assassination and the Warren Report. Prior to the broadcast, few of the LRL scientist's friends and co-workers were aware that the well-known Alvarez ingenuity had been focused on the assassination.

The essence of Alvarez' contribution is the discovery that the Abraham Zapruder motion-picture films of the assassination, printed in *Life* and in the Warren Report, contain internal clues

MUCH-THUMBED COPY of "Life" magazine may still hold new clues to the assassination mystery, believes LRL physicist Luis Alvarez (above).

which may reveal the number of shots fired and the exact instant when they were fired. The clues are streaks on the film, which Alvarez believes could have been caused only by a sudden involuntary jog of Mr. Zapruder's camera. Alvarez suggests—and the independent tests impressively corroborate — that such a jog is precisely the response of a hand-held motion picture camera to a nearby rifle shot—a combination of the direct shock wave from the bullet and a flinching reaction of the photographer.

If this theory is correct, the implications for the controversy surrounding the Warren Commission Report are very great. From his analysis of the 165 frames available to him, Alvarez was able to show that three and only three shots were fired (as the Commission maintained), and, furthermore, that the bullet which missed its mark was the *first* shot, fired just before the one that hit the President in the back. (The Warren Commission inclined to the belief that

Continued on Page 6

Berkeley Physicist Finds New Clue in JFK Assassination

Continued from Page 1

the *second* shot was the one that missed.) This finding is crucial, since it significantly lengthens the amount of time available to the assassin to aim and fire. Instead of the 5.6 seconds previously thought available, Alvarez' evidence points to more than seven seconds between the first and third shots. This would make the "single assassin" theory much more plausible to those who have been critical of the Warren Report's conclusions.

Alvarez' analysis of the film (later corroborated by photo analysis experts at Edgerton, Germeshausen and Grier, Inc.) indicate that the three shots were fired around frames 180, 220, and 313 of the Zapruder film. The latter two frames are the ones that were previously believed to correspond to the time of the rifle shots. Frame 180, however, is a surprise, since it occurs in a period when it had been thought that no shots were fired—while the presidential limousine was passing under a tree which screened it from the sixth-floor window of the book depository. Significantly, however, frame 180 coincides exactly with the brief moment when the limousine passed through a fairly large gap in the foliage, offering for a few seconds a clear line-of-sight to the assassin. Alvarez suggested that that first bullet may have hit the tree, and may, in fact, still be lodged there. At his urging, CBS scanned the tree with a metal detector—but without success.

Empirical Tests

The independent tests of Alvarez' hypothesis were performed, at his suggestion, by experts at E.G. & G., the firm that also does much technical-photography analysis in connection with LRL Livermore field activities. In the tests, experimental subjects holding cameras identical to Zapruder's filmed a target while rifles were fired in the same relative position as the assassin and Zapruder. Even though the subjects had prior expectation of an impending disturbance, and were instructed to keep their cameras as steady as possible, every subject reacted to the shots with exactly the sort of involuntary movement that Alvarez had predicted. Furthermore, these movements produced streaks on the film closely resembling the effects found in the Zapruder photos.

Whether or not Alvarez' theory is ever confirmed conclusively by further evidence, it has already been acclaimed all over the country as a masterful piece of analysis, in the best tradition of closely-reasoned, imaginative scientific detection. What makes the accomplishment particularly impressive is the fact that Alvarez used no complicated technical apparatus and had no special access to materials or evidence unavailable to the rest of the public. He worked entirely from the *Life* magazine color photos and the black-and-white reproductions in the 27 volumes of the Warren Commission Report—pictures which have already been scanned and re-scanned by millions of people, and which have been subjected to the most exhaustive technical analysis in FBI laboratories.

Alvarez himself attributes his success to two seemingly unrelated interests out of his scientific past: first, his experience in studying shock waves and designing instruments to measure them; and, second, his longtime interest in photography, which has led him to study the phenomenon of camera "jitter" in hand-held motion picture cameras. It is unlikely, says Alvarez, that anyone else with those two particular specialties in his background had ever happened to examine the Zapruder photos in detail up until this time.

The Wrong Clue

Like so many important discoveries, this one began with a mistake—a mistake which cost Alvarez many hours of painstaking labor, and yet which led him, finally, to the discovery of important new information.

The mistake involved a flag—specifically, the American flag on the right fender of the President's limousine.

As Alvarez recalls it now, he first became interested in the challenge of applying scientific analysis to the assassination photos on the day before Thanksgiving, 1966, after a lunchtime conversation in the LRL Berkeley cafeteria with some of his graduate students, who were arguing heatedly about the Warren Report's conclusions. That evening at home, he pulled out the copy of *Life* with the Zapruder photos and sat down to examine them carefully for the first time.

Almost immediately, his attention was caught by the appearance of the flags on the President's car. The right-hand flag seemed to be different in frame 228 than in all other frames. Is it possible, he wondered, that the flag was reacting to a sudden shock wave? And could that shock wave have been caused by one of the bullets? With growing excitement, he measured the flag's apparent width in successive frames, applied elementary formulas to calculate the acceleration of the edge of the flag, and convinced himself that the flag might indeed be reacting to some unusual stimulus. That conviction turned out to be wrong. The flag distortion, Alvarez now feels, was due to wind rippling, and can be found in several frames not conceivably associated with rifle shots. But that realization did not come for several more days —and by that time, Alvarez was hooked.

Alvarez was now anxious to check his rough calculations with other photographs contained in the 27 volumes of the Warren Commission Report. But it was Thanksgiving weekend, and the University libraries were closed. Too impatient to wait, he confided his ideas to a friend, Edwin Huddleson, a San Francisco lawyer, who told him about a library that would be open—the law library in San Francisco's City Hall.

All through the remainder of that Thanksgiving vacation, Alvarez worked in the law library, measuring and re-measuring, calculating and re-calculating, taking voluminous notes. By the end of the vacation period, the initial "flag" hypothesis was all but forgotten, and Alvarez was on the track of something much more exciting.

Frame 227

The important breakthrough came when Alvarez noticed that frame 227 of the Zapruder film shows the highlights on the car's windshield spread out into streaks about 2 millimeters long, oriented about 25° with the horizontal. Further examination revealed that many other objects that had been in sharp focus in previous frames were streaked or blurred in this frame.

Alvarez' notes, which he made available to the MAGNET for this article, furnish a vivid picture of the slow process of discovery and the awakening of insight:

Monday, November 28: "Note streaked highlights in frame 227 . . .

Tuesday, November 29: "227 remains the most puzzling picture . . . The extraordinary thing is that neither the men in the right middle or the squares in the background seem to be at all smeared . . ."

Soon after the latter entry, the insight came. Here's how he described it in a letter he wrote to Huddleson a few days later:

". . . even after I had found the streaking in 227, it took me some time to realize why everything on the north side of the Elm Street curb was streaked, while the objects on the south side of the curb were unstreaked — the background squares, the tree, the two men . . .

"I finally saw that the man waving in the foreground wasn't streaked—the crease in his shirt at the elbow shows that he and the camera weren't in relative motion. So finally, in a most tedious way, it became clear that what had happened was simply this: the camera axis, which

had been panning smoothly to keep lined up on the moving car, had been given a sudden twist to the left (counterclockwise). This completely stopped its panning motion, so that both the foreground man and all the background objects became sharp. But the fact that the car and the motorcycle policemen were moving to the right produced the drawn-out streaks of light on the film."

What could have produced this sudden uncontrollable twist to the left in such a good photographer as Mr. Zapruder, who displayed a high level of skill and coolness in all other aspects of the filming? Were there other instances? Alvarez quickly searched all the other frames for similar streaks—and found them in several places. He then plotted the horizontal spread of the highlights in every single one of the 165 frames reproduced in the Warren Report, and found three streaking "peaks." The first group of streaks starts at frame 182 and ends at 202—just over one second of time. The second group is the one discussed above, in connection with frame 227. In frame 313, the most clearly defined shot hit the President. Streaking shows the camera jerked violently to the right at frame 313. Alvarez believes that this frame registers the direct effect of the bullet's shock wave—the same effect that breaks windows during sonic booms. In the other streaked frames, he believes that the greater part of the camera's motion was caused by Zapruder's neuromuscular reaction to the sound of the rifle shot.

Testing the Theory

By December 4, Alvarez was sufficiently convinced of the correctness and importance of his theory to communicate it to someone else. But, before going too far out on a limb, he wanted to examine the original Zapruder film and have independent tests of flinching reactions performed at a well-equipped laboratory. He thought of Frank Stanton, president of CBS, chairman of the Rand Corporation board, and a longtime acquaintance—someone who would certainly be in a position to cut through red tape and arrange the necessary clearances. Therefore he summarized his conclusions in a 30-page typewritten letter and sent it off to Huddleson for transmittal to Stanton. The CBS president's reaction was quick and enthusiastic. Within a few weeks, the E.G. & G. tests were planned and executed. On January 19, Alvarez met with CBS and E.G. & G. officials in the National Archives in Washington and studied the Zapruder originals, which were consistent with all of the ideas suggested by the 165 frames printed in *Life*. (The E.G. & G. experts analyzed this film for evidence of additional shots, and found none.)

Alvarez' conclusions from his analysis of the Zapruder film are contained in two letters—the 30-page one mentioned above and a follow-up letter dated January 2. The letters discuss several different aspects of the film—not all of which were covered in the CBS report. Among the material not followed up in detail by CBS is a discovery (here described publicly for the first time) that Alvarez himself considers to be of considerable importance. It relates to the question of whether Zapruder's Bell & Howell camera, which was supposed to be operating at a speed of 18.3 frames per second, was actually running at that rate during the filming. The camera's speed is critically important, since the Zapruder film has been used as the basis for all reconstructions of the assassination; if the camera was running fast, the time between shots would be correspondingly shorter. Many experts have addressed themselves to this problem, but it has generally been regarded as essentially insoluble. Of course, the camera was itself tested later, but such tests do not necessarily prove that it was running at its rated speed *at the time* when the critical photos were taken. For example, some critics have suggested that Zapruder might, in his excitement, have depressed the camera's button to the high-speed position, thus increasing the frame rate to 1.5 times the original rate.

An Internal Clock

Alvarez believes that he has found an internal "clock" in the film that proves conclusively that the frame rate was *not* significantly fast compared to the 18.3 frames-per-second estimated by the FBI. The clock is easily visible and—after it has been pointed out—almost absurdly simple. In frames 278-296 of the Zapruder film, there is a man in a white shirt, standing in front of a small boy and a woman. The man is clapping. His hands are together in frames 280, 285, 291, and 296, and are farthest apart in frames 278, 283, and between 287 and 288. From these pictures, it is a simple matter to figure out the frequency of the man's clapping. If the camera is running at 18.3 frames per second, the man is clapping at four claps per second; if the camera is running 50% faster (at 27 frames per second), the man is clapping at 6 claps per second. If the camera is running twice as fast (at 36.6 frames per second), the man is clapping at eight claps per second. Yet it is virtually impossible for a human being to clap at either of the two higher rates. This sounds implausible, but it's true: if you wish, you can test it yourself exactly as Alvarez did, by synchronizing your clapping to a metronome. The reason for this odd circumstance is the fact that the muscular power a person must exert to clap (with a constant hand spread) varies as the cube of the clapping frequency. To double the clapping rate, you must increase the power expended eight times. A reasonable clapping rate (even for a very enthusiastic spectator) is four or possibly five claps per second; six and above is unreasonable. Thus, by internal evidence, it appears that the frame rate of Zapruder's camera can be closely restricted to 18.3 frames per second plus about 15-20% *at the most*. This variation is not large enough to significantly affect the time-reconstruction of events based on the film.

Alvarez believes that there are probably still many more clues in the Zapruder film and other photos of the assassination that could be brought to light by careful photo analysis. For example, it has generally been believed that it is impossible to pinpoint the exact position of the presidential limousine in each frame of the film, because of the essentially "featureless" background. Alvarez, however, has found several tiny "features" which he believes could be used to determine the position of the car from the beginning to the end of the critical period.

Back to Alamagordo

As for himself, Alvarez intends to pursue the analysis of the films no further. Nor is he tempted to become involved in other aspects of the investigation—even to the extent of reading any of the mountain of books that have been published on the subject. He looks at his accomplishment, however, as an exhilarating exercise in the principles of scientific inquiry—not too different, in essence, from the other puzzles in logic that have intrigued him during his long career. In fact, he ends his summary of the investigation with a reminder of an "earlier use of shock wave-induced motions of lightweight objects"—one that should be very familiar to LRL readers. At the Alamagordo test of the first atomic bomb, hundreds of scientists were manning the most expensive and sophisticated equipment available for measuring the overpressure in the shock wave, which would give the equivalent kilotonnage of the explosion. One man, however, had a simpler method. As Lansing Lamont described it in his book *Day of Trinity*, "Enrico Fermi didn't notice the crack of the shock wave . . . [He] was too engrossed in dribbling scraps of paper from his pockets. He watched them slowly fall, then sweep across the reservoir as the shock wave struck them. Within seconds, Fermi had paced the distance the scraps had blown and estimated the force of the explosion as the equivalent of 20,000 tons of TNT."

Fermi's measurement, Alvarez notes, has stood the test of time.