SUPERIOR COURT OF _____, COUNTY OF _____
CENTRAL DIVISION

Michael A. Minovitch	§
	§
	§
Plaintiff,	§
	§
v.	§
	§
	§
Richard H. Battin	§
	§
Defendant	§

DECLARATION OF ROBERT J. ABEND

I, Robert J. Abend, declare and state the following:

I. BACKGROUND

1. I have been retained by Dr. Michael A. Minovitch as an expert in this case to provide my opinions in certain technical areas regarding the authenticity of claims made by Dr. Richard H. Battin associated with the discovery of gravity assisted interplanetary spacecraft trajectories.

2. I have over 35 years of experience designing, testing, and repairing electronic devices and, in particular, integrated circuit electronic devices and computers. I also have extensive experience in developing software, and I am familiar with the FORTRAN programming language. I gained some familiarity with computer equipment while attending Rutgers University and/or Farleigh Dickson University in the early 1960's. From 1966-1970, I worked at AAI Corporation performing hardware design, system logic design, software development, and field service for integrated circuit test equipment that employed computer systems. From 1970-1976, I worked for Harris Semiconductor, where I was involved with designing and testing integrated circuit electronic devices, also know as computer chips. During this period I was responsible for the implementation, operation, and maintenance of a data processing facility containing several computer systems. The product of the data processing area was frequently fan-fold tractor-fed paper printouts. I returned to Harris Semiconductor in 1979 as an Engineering Section Head and progressed to Director of Test, where I was responsible for manufacturing test, burn-in, wafer probe, and test engineering for the Custom Integrated Circuit Division. In performing these duties, I developed and characterized new integrated circuit products including memory devices and microprocessors used in computers. I also designed custom automatic test systems for integrated circuit products. These systems employed dedicated and general purpose computers. I also designed and implemented a data acquisition and processing center employing several computer systems. More recently, I have been certified as a computer forensics examiner, and have received extensive training in that area.
3. I received my B.S.E.E., with Highest Honors from the Florida Institute of Technology in 1989 and my M.S.E.M. from the Florida Institute of Technology in 1990.

4. In the early 1990's I performed as an Adjunct Professor at the Florida Institute of Technology and the Brevard Community College in Melbourne Florida area.

5. From 1992-1994, I worked for the U.S. Air Force at Hill Air Force Base as a supervisor on the Hardware Technology Team, where I developed a manufacturing and assembly facility for multi-chip module electronic devices. I was also responsible for designing avionics systems, including computer based test systems and controllers for aircraft electronic systems. Since 1994, I have worked for the U.S. Air Force at Los Angeles Air Force Base, in the Space & Missile Systems Center where I oversee satellite launch vehicle (rocket) development and systems design, including navigation and control system computers. I also participate in launch preparation activities for launches at Cape Canaveral, Florida and Vandenberg Air Force Base, California. The launch vehicles I support are used for military, commercial, and NASA payloads. I have also spent considerable time working with NASA and JPL. I have developed and analyzed computer communications networks at this facility and installed and administered several computer servers and networks.

6. I have considerable experience using tractor feed printers, IBM card punches, and other computer equipment used in the 1960s and 1970s.

7. I am the named inventor on four U.S. Patents involving the packaging, processing, and testing of integrated circuits.[1]

8. A copy of my current resume is attached as Exhibit A.

9. I have not previously worked or consulted for any of the parties in the case.

10. I am being compensated for the time that I spend on this case at my usual consulting rate of $160 per hour. My compensation does not depend on the outcome of the case.

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[1] U.S. Patent No. 4,549,338, U.S. Patent No. 4,845,052, U.S. Patent No. 4,862, 231, and US Patent No. 5,544,174.

11. I have testified or been deposed as an expert in eight cases. A listing of the cases in which I have testified or been deposed, particularly within the last four years, is attached as Exhibit B.

12. In preparing this declaration, I have read and considered the documents listed in attached Exhibit C.

II. GRAVITY ASSISTED TRAJECTORY OVERVIEW

13. The discovery that gravity assisted trajectories were a practical method of enabling multi-planetary spacecraft missions revolutionized space travel. Until the determination that planetary fly-bys were a practical alternative, it was thought that travel from Earth to many of the planets in our solar system would require powerful propulsion systems with great endurance. To this end, efforts in the early 1960's were to develop nuclear and other propulsion systems to meet this need. Most of those propulsion systems have yet to be developed, and interplanetary space travel to much of the solar system has been made possible by the use of gravity assisted trajectories. These trajectories involve the close fly-by of a space craft to a planet in such a way that the planet gives up a miniscule portion of its total orbital energy resulting in dramatic acceleration of the spacecraft. With these trajectories, only minimal propulsion is required for navigational error correction and the total round trip travel time is greatly reduced as a result of the energy gained by the spacecraft during a planetary fly-by. Gravity assisted trajectories have enabled interplanetary space missions such as Mariner 10, Pioneer 10, and 11, and Voyager 1 and 2 and are therefore of monumental importance to the space community.

14. The discovery of gravity assisted multi-planetary trajectories was of particular importance in the early 1960s since manned missions to Mars were an important part of NASA's plans.

Since manned mission duration was closely related to mission assurance and astronaut survivability, the fact that a gravity assisted Earth-Venus-Mars-Earth trajectory could roughly halve the time required by an Earth-Mars-Earth trajectory was of great importance in the 1961 timeframe. Many scientists at the time were endeavoring to solve this problem to make a manned mission to Mars feasible, and to reduce unmanned mission durations. On that basis, such a discovery warranted timely and explicit documentation to ensure historical accuracy in assigning credit to the discoverer. Experienced members of the scientific and academic communities are very familiar with this process and typically publish numerous papers that, if accepted by their respective community, become important elements within their credentials, and incrementally elevate their individual stature.

15. Dr. Michael A. Minovitch claims to have discovered gravity assisted trajectories in 1961. His claim is supported by a 47 page paper dated August 23, 1961; "A Method For Determining Interplanetary Free-Fall Reconnaissance Trajectories". He published this paper at the Jet Propulsion Laboratories (JPL) as Technical Memorandum 312-130. This publication describes gravity assisted trajectories and their advantages in a general mathematical form, and contains an exemplar mission from Earth to Venus, then Mars, a return to Earth, and then on to other planets. JPL is a Federally Funded Research and Development Company (FFRDC) providing technical support to the National Aeronautics and Space Administration (NASA). Dr. Minovitch's paper is attached as Exhibit D.
16. Dr. Richard H. Battin also claims credit for the discovery of gravity assisted trajectories. His claim is supported by a two page computer printout that is reportedly the result of his gravity assisted trajectory calculations for an Earth-Venus-Mars-Earth trajectory. This computer

printout is dated 26 January 1961 and is attached as Exhibit E. If authentic, the document predates Dr. Minovitch's paper by approximately 7 months.

III. Analysis of Claims

17. Dr. Battin provided a two page computer printout as proof that he completed calculations showing the benefits of gravity assisted trajectories in January of 1961. The computer printout provided by Dr. Battin consists of two pages shown in Exhibit E. The first page contains a date of "01-26-61" and what appears to be a page number "24" in the upper right corner. It is then likely there were 23 pages preceding the two provided by Dr. Battin. With an indicated page number of 24, a question arises as to what was contained on the other 23 pages, and why those were not included? Dr. Battin testified in his February 9, 2005 deposition that the printout was not an actual printout from the IBM 650 he used to perform the trajectory calculations, but a manual transcription he performed by visually reading the actual computer printout, punching IBM cards manually, and then printing the content of those cards on paper. It seems somewhat strange he did not just keep the original 650 printout as a truly authentic result of the calculations he claims to have performed. Instead, he claims to have discarded the actual 650 printout along with the program or software he used to perform the calculations immediately after obtained the 650 output for the trajectories on January 26, 1961. It is hard to understand why Dr. Battin transcribed the results output by the 650. It is also strange he discarded his 650 program, since there may have been a future opportunity to reuse the software to perform additional calculations for other trajectories.

18. Computer printout paper has been produced by manufacturers with each page, or in some cases every other page serialized. In other words, sequential numbers are imprinted on each page or every other page of the paper. In my experience, the purpose of imprinting

individual pages with a unique serial number is so the user of the paper can later uniquely identify data on each page by reference to the serial number. The computer printout provided by Dr. Battin has the serial number spanning the perforation between the two pages. A serial number spanning the perforation between two pages would seem to defeat the purpose of having serial numbers, and in my experience, I have never seen printer paper serial numbers span the perforation. A serial number spanning the perforation would be divided into two numbers with little or no meaning when the pages were separated at the perforation. A photograph of the serial number across the perforation is provided in attached Exhibit F. Exhibit F also contains a photograph of paper serialization I have seen where the serial number does not span the perforation. I have used millions of pages of tractor feed serialized paper and never seen a serial number cross the perforation between pages.

19. Dr. Richard Battin claims to have performed his interplanetary trajectory calculations on an IBM Model 650 Drum Calculator for an Earth-Venus-Mars-Earth mission. The IBM 650 had limited capabilities, particularly in comparison to the IBM 7090 computer Dr. Minovitch used to perform his calculations. The average memory access time on the 650 is 2.4 milliseconds and the IBM 7090 memory access time was 2.18 microseconds. That makes the IBM 650 roughly 1100 times slower than the 7090. The IBM 650 had a maximum of 4000 memory locations, whereas the 7090 had 32,768 memory locations. Even with compiler optimization on the 650, it is vastly inferior to the 7090 in several respects, and therefore very limited in terms of the size and complexity of problems it could solve. I have conducted a fairly extensive historic review of applications on which the IBM 650 was employed, and I can find no applications approaching the complexity of calculating gravity assisted multi-planetary trajectories. It is also not clear how the date was printed on Dr. Battin's evidentiary

printout, since I can find no such capability referenced in the IBM 650 specifications. I am also unable to find any reference to a 650 peripheral device that might have augmented the 650 to provide that capability.

20. Dr. Minovitch computed 8 gravity-assist Earth-Venus-Mars-Earth trajectories at UCLA on June 9, 1962 with a program run time on the 7090 that was 19.58 minutes or 2.45 minutes per trajectory. Dr. Battin's run time for one launch time would have taken place over days or even weeks on the 650. Dr. Minovitch loaded the ephemeris[2] for his calculations in the 7090 memory. That approach significantly reduced computation time since, with the ephemeris loaded in memory, it was only necessary for the 7090 computer to perform a simple lookup operation. It is not likely Dr. Battin could have loaded the ephemeris in memory due to the limited storage space on the IBM 650. The latter limitation would have widened the performance gap between the 650 and 7090 for this application even further due to additional required computations on the IBM 650 to generate ephemeris data points on the fly using some form of algorithm.

21. Dr. Battin published his book "Astronautical Guidance" through Mcgraw Hill with a Copyright of 1964, long after Dr. Minovitch published his paper on gravity assisted trajectory in August 1961. When referring to double reconnaissance Earth-Venus-Mars-Earth trajectories in Chapter 5, (pages 169-171) Dr. Battin says they are "little more than astronomical oddities". He also states that launch windows for an Earth-Venus-Mars-Earth trajectory would be less than a few days, rendering double reconnaissance trajectories impractical. Finite launch windows coupled with almost inevitable delays due to weather conditions, ground system anomalies, range safety issues, and launch vehicle problems have

[2] Ephemeris: A periodical publication tabulating the predicted positions of celestial bodies at regular intervals, such as daily, and containing other data of interest to astronomers.

and will continue be an encumbrance to launching payloads into space. Nevertheless, in his 1994 paper Battin states "it was very exciting when the double fly-by finally worked" referring to the claimed calculations he performed on the IBM 650 in 1961. He also states in the 1994 paper "I sensed the importance of this result and saved the tabulator listing which included the date of the printout – January 26, 1961. Today it is among my treasured mementos". Dr. Battin also discusses Dr. Minovitch's work on the subject as having taken place during the summer of 1962. This statement appears incorrect since Dr. Minovitch published his Earth-Venus-Mars-Earth findings, after performing extensive work, on August 23, 1961. Launch windows are established by calculating multiple trajectories over a period of calendar time to establish the size of the time window where the launch will result in a successful mission. The January 1961 computer printout Dr. Battin provides as proof of his discovery only contains one trajectory for the June 1972 launch window referenced in his 1964 book. It is then not clear how Dr. Battin arrived at his conclusion that this launch window was a few days or less.

22. In Dr. Battin's 10 September 1999 letter to Robert J. Lauson, Dr. Minovitch's attorney at the time, references the paper "The Determination of Round Trip Planetary Reconnaissance Trajectories" that Dr. Battin published in 1959. In that same letter, Dr. Battin claims that his 1959 paper makes the work and conclusion reached by Dr. Minovitch obvious. In this regard, he states "It doesn't take a great deal of imagination to see that the trajectory back to Earth could just as easily be a trajectory to another planet and then another planet".

IV. OPINIONS AND CONCLUSIONS

23. Dr. Battin's written statements in Chapter 5 of his 1964 book "Astronautical Guidance" are a clear communication to his colleagues and the space community that use of gravity assisted trajectories to enable double reconnaissance missions are of little or no practical value. It is likely Dr. Battin was completely familiar with Dr. Minovitch's work and findings in 1961 prior to writing his book "Astronautical Guidance" due to his intimate involvement in the space community and the fact that MIT and JPL routinely shared information. In his 1964 book he states in relation to gravity assisted trajectories "It is sad to report that these double reconnaissance trajectories are little more than astronomical oddities". Had the space community followed Dr. Battin's authoritative finding, the application of gravity assisted trajectories to interplanetary missions would have never occurred. There is a definitive lack of consistency between Dr. Battin's claim in 1994 that he experienced a level of elation upon discovering gravity assisted trajectories, and the written record in the 1964 book "Astonautical Guidance" stating there is no practical value associated with that discovery.

24. In reviewing Dr. Battin's September 1959 paper that he references in his 1999 letter to Attorney Robert J. Lauson, I find no reference to multi-planetary, gravity assisted, or double reconnaissance trajectories. The paper deals solely with round-trip trajectories from Earth to an individual planet and back to Earth. On Page 556 of his paper, Dr. Battin refers to "disturbances induced by the destination planet" not gravity assist. Synonyms of disturbance are trouble, fighting, disorder, and conflict. Dr. Battin was clearly referring to the encounter with the destination planet as a problem that had to be dealt with, and not a benefit to the mission. When Dr. Battin discusses an Earth-Mars-Earth trajectory, the total round trip times he calculates for 14 different trips on Page 558 of his paper, in Table 1 are all approximately

3 years. Dr. Battin also discusses Earth-Venus-Earth trajectories in his 1959 paper, but never considers or refers to an Earth-Venus-Mars-Earth gravity assisted trajectory that could have roughly halved the required time for the Earth-Mars-Earth trajectory round trip time of three years, and provided the bonus of double reconnaissance for Venus and Mars. Based on the 1959 paper's content and the exclusion of any reference to gravity assisted fly-bys, Dr. Battin's reference to the paper in his letter to Lauson is, at best, questionable. Even the title of the paper calls out "Round-Trip Planetary Reconnaissance Trajectories" not multi-planetary or double reconnaissance. The 1959 paper does nothing to bolster Dr. Battin's claim to discovering gravity assisted trajectories, since it does not reference gravity assisted trajectories in any way. If one were to assume, hypothetically, that Dr. Battin understood the implications of gravity assisted trajectories in 1959, it would then be very surprising for him to wait until 1961 to perform his claimed calculations on the IBM 650 computer, when the 650 had been installed at MIT in February, 1960, a few months after his September 1959 paper. Dr. Battin's implication in the Lauson letter that his 1959 paper makes Dr. Minovitch's discovery obvious is without merit, particularly since the concept of gravity assisted trajectories was not apparent to Dr. Battin at the time he wrote the 1959 paper.

25. Since his original paper of August 23, 1961, Dr. Minovitch has published numerous papers describing and touting his discovery of gravity assisted trajectories. The paper he presented in at UCLA in April 1963 "The Determination and Potentialities of Advanced Free-Fall Interplanetary Trajectories" exemplifies these publications. In that paper he talks about trajectories he "discovered" at UCLA. Dr. Minovitch won 1st prize from the American Institute of Aeronautics and Astronautics (AIAA) in May of 1963 for yet another paper on gravity assisted trajectories. On July 6, 1967, the Los Angeles Times gave Dr. Minovitch

credit for discovering gravity assisted trajectories in the article "Mercury Fly-By Called Choicest Plum in Space". In 1970, the Director of the Jet Propulsion laboratory, Dr. William Pickering in his paper "The Grand Tour" gave credit to Dr. Minovitch for being the first to show the benefits of gravity assisted trajectories. On November 4, 1973, the New York Times published a full page article entitled "Craft Speeds Toward Mercury On the Wings of Students Idea" including a picture of Dr. Minovitch, and giving him credit for discovering gravity assisted trajectories. In August 1989, the Star-News gave Dr. Minovitch credit for discovering gravity assisted trajectories in 1961, and there are many other such references. It is hard to understand how Dr. Battin could have believed he was the discoverer and waited approximately 30 years until 1994 to take credit for the discovery of gravity assisted trajectories, and that he never disputed Dr. Minovitch's claims during that time.

26. In spite of all of the widely published articles, papers and, credits given to Dr. Minovitch for discovering gravity assisted trajectories, Dr. Battin claims in his February 9, 2005 deposition that he did not become aware of Dr. Minovitch's work until the year 1990. Considering Dr. Battin's intimate involvement in the space community, and his innumerable contacts with other leaders in the community during the roughly 30 years from Dr. Minovitch's work until 1990, and the extensive reading of publications associated with advances in space travel he surely did, it is difficult, if not impossible to understand how he never became aware of Dr. Minovitch's work until 1990. Since he has been an adjunct professor at MIT for many years teaching celestial mechanics, it seems that one of his many students would have asked about Dr. Minovitch's widely publicized work, thereby bringing the issue to Dr. Battin's attention.
27. In his 1964 book Dr. Battin states gravity assisted trajectories are odd phenomena of little or no value; in his 1994 paper he claims the product of his 1961 work on gravity assisted

trajectories is a treasured memento. In his 1964 book Dr. Battin states that launch windows for gravity assisted trajectories are less than a few days and therefore impractical. In the same book he specifies June 1972 as being one of those impractical launch windows, yet in his 1994 paper he states that "on June 9, 1972 the ideal conditions prevail", and he goes on to describe a practical mission initiated on that date. Again, the statements he makes in his 1964 book "Astronautical Guidance" appear to be contradicting his statements in 1994.

28. The influence of celestial body gravity on spacecraft had been noted by several scientists prior to 1960. Some of these findings were that celestial body gravity was an annoyance that had to be corrected for during space-flight, a force that could be used to alter a trajectory, and a force that could be employed to slow the spacecraft during its mission. The discovery at issue in this matter is who presented the space community with mathematical evidence that a gravity assisted trajectory could be used to enable interplanetary spacecraft missions. The printout Dr. Battin has provided as evidence he discovered the practicality of such a mission is a single result for launch time. In order to determine the practicality of such a mission, it is necessary to calculate the trajectories for many missions to determine the launch window. Dr. Minovitch did perform the calculations for many trajectories showing an Earth-Venus-Mars-Earth mission using Venus to provide the initial gravity assist was completely feasible. History has long since shown Dr. Minovitch's calculations to be correct, and using his proposed method enables interplanetary missions to Mars and other planets.

29. The evidentiary printout provided by Dr. Battin as proof of his claim is of questionable origin since there appear to be missing pages, it is unlikely the IBM 650 would have been able to print the date displayed on the printout, and the computational limitations of the 650 would likely have made the calculation of trajectories for gravity assisted multi-planetary missions

impractical. The authenticity of Dr. Battin's printout is also tainted since it is not the actual computer printout, but apparently one that he essentially typed manually.

30. It is difficult to believe Dr. Battin considered gravity assisted trajectories as an impractical oddity in his 1964 book when he claims to have discovered the possibility with great excitement and pride in 1961.

31. It is not unlikely Dr. Battin was referring to Dr. Minovitch's discovery in his 1964 book "Astronautical Guidance" and questioning the value of that work. It is inconceivable that Dr. Battin could have made the historical discovery of interplanetary travel using gravity assisted trajectories, watched as his claimed discovery was employed successfully over 30 or more years, and not taken credit for the discovery in some type of formal written publication until 1994.

32. Based on the evidence reviewed, it is my opinion that Dr. Michael A. Minovitch was the person who discovered the feasibility of interplanetary missions by employing gravity assisted trajectories. It is also my belief that it is his extensive work and resultant findings in 1961 that acted as the seed for future interplanetary missions.

V. DECLARATION

I declare under penalty of perjury that to the best of my knowledge the foregoing is true and correct.

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Robert J. Abend, PE

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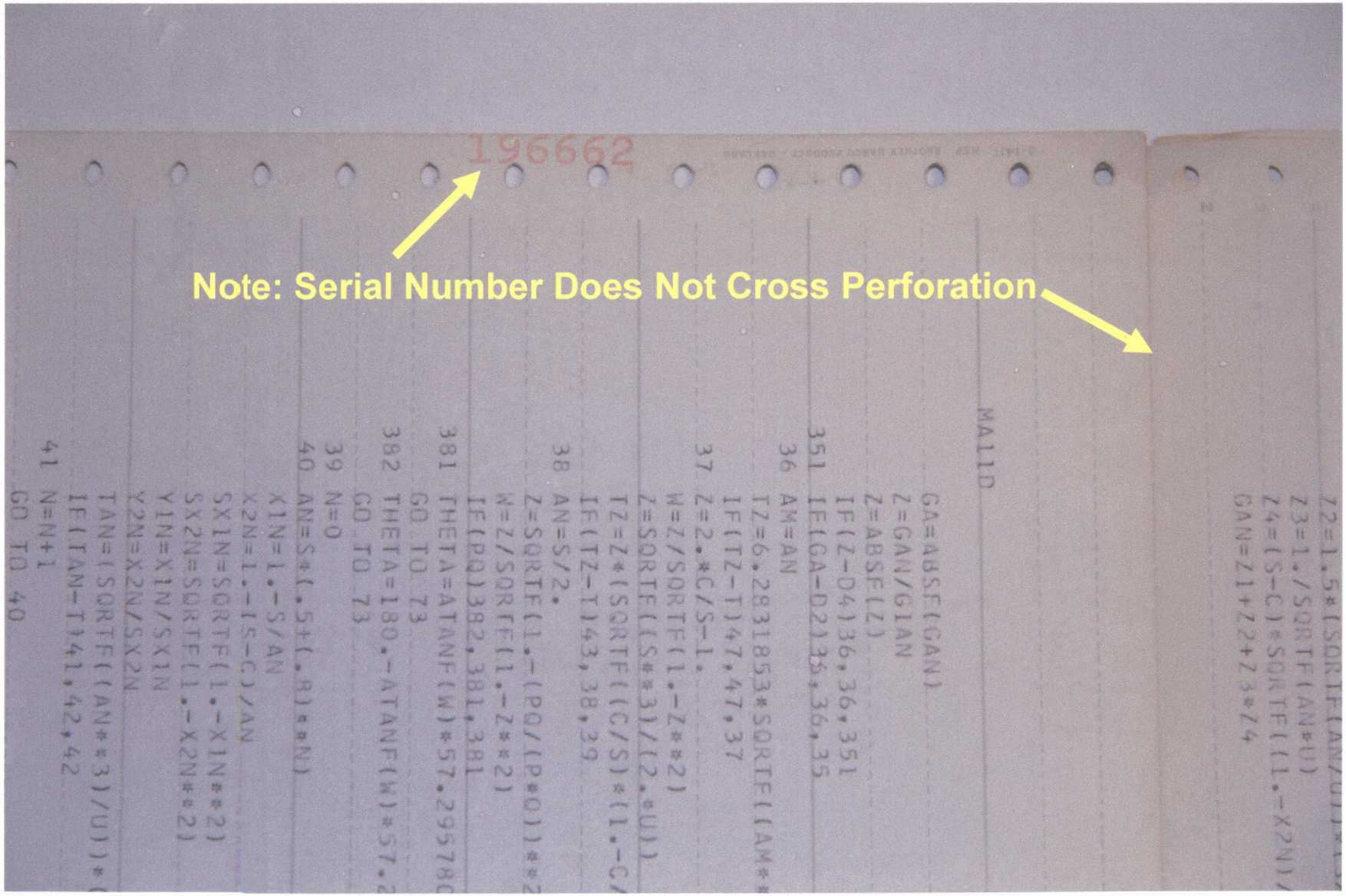
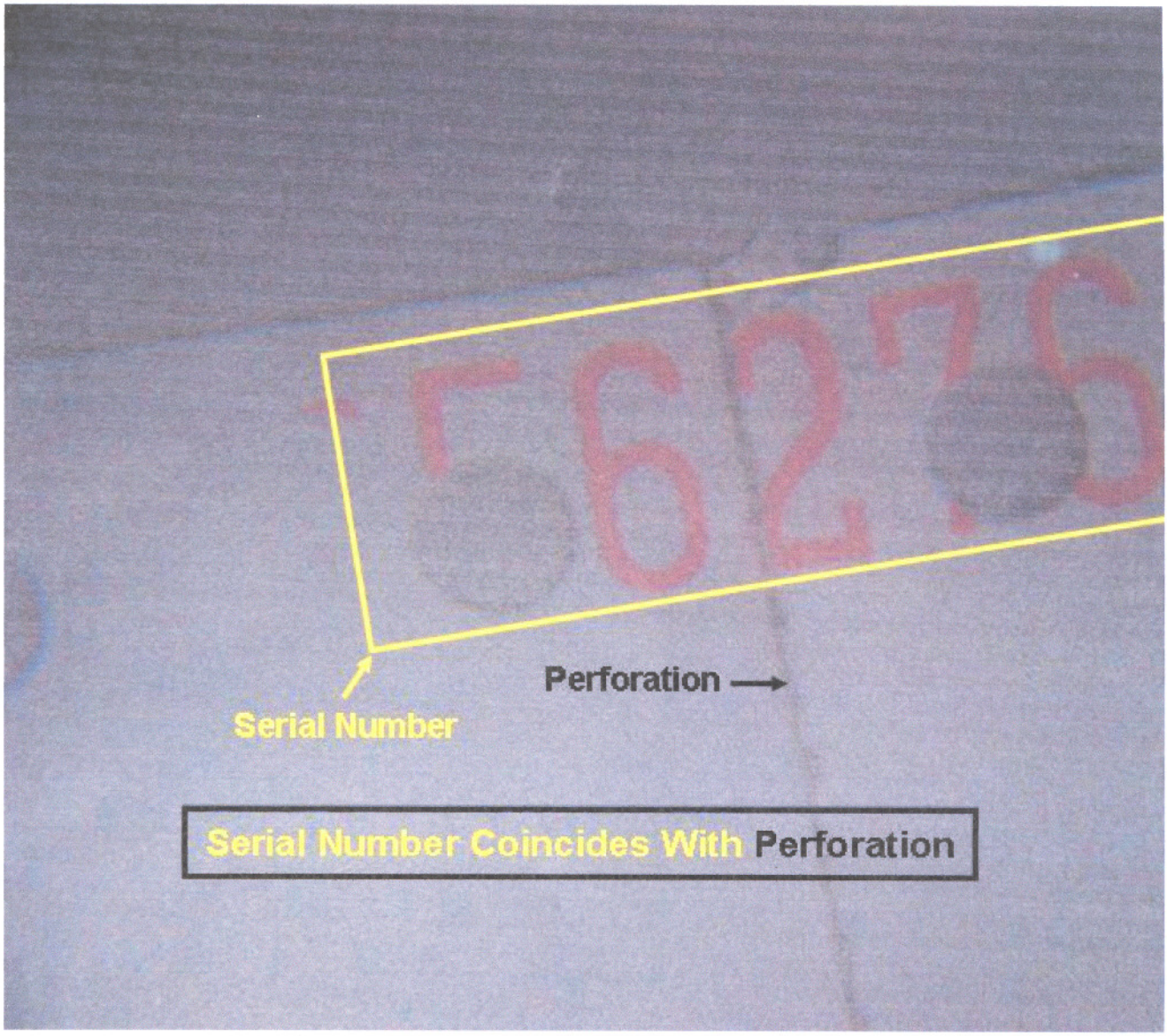
Date

Typical Computer Print-Out Serial Number Circa 1962



Battin Jan 1961 Print-(Serial Number



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Double reconnaissance Trajectoire.