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Dr. Larry Dumas
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October 30, 1997

Dear Dr. Dumas:

I want to thank you for taking the time to meet with Dr. Sam Dallas and Rex Ridenoure to discuss the fact that I have still not received "official credit" for my invention of gravity propelled interplanetary space travel, popularly known as "gravity-assist" or "swing-by" trajectories from JPL.

According to the message you sent to Rex after the meeting,[1] you indicated that the usual method for recognizing the inventor of an important invention is through the "peer-review" process, [1] and that this is the method that JPL should take as the condition for granting "formal" recognition with an appropriate award for the invention.

I am happy to report that this has already been done. And it was done during a time period much closer to the time of the invention. This means that the conclusions reached during that "peer-review" process were more accurate then they would be today, because the traditional direct-transfer design of interplanetary trajectories was taken for granted as self-evident at that time. (My indirect gravity propelled method of interplanetary trajectory design was completely unknown in 1961.) Thus, the novelty of the invention was obvious, and very easy to understand at that time.

What follows is the **"peer-reviewed"** evidence showing that "gravity-assist" trajectories was a new innovation in the design of interplanetary trajectories, and that I invented it.

In 1963, Walter Hollister wrote one of the earliest papers describing the new indirect gravity propelled trajectory design method for a mission to Mars. But this paper was no ordinary "peer-reviewed" paper published in the professional literature. It was a Ph.D. Dissertation at MIT that was approved by MIT's Department of Aeronautics & Astronautics. This Department was one of the most prestigious and authoritative research centers in the field of astrodynamics in the entire world. On page 7 of his Dissertation, Hollister made the following statement:[2]

> "Because of the large volume of work on different aspects of a mission to Mars it would be impossible to make reference to all of the literature on the subject. It should be noted, however, that the author has found no mention in the literature of the specific missions suggested in this work, namely trips to Mars via bi-elliptical transfer or via a Venus encounter that includes a significant velocity change near Venus."

This indirect gravity propelled trajectory design technique passing Venus which Hollister (and MIT's

Department of Aeronautics & Astronautics) determined was new, was used as Hollister's innovative basis for meeting the strict innovative requirements for a Ph.D. Dissertation at MIT. (This is a very important requirement.) It is significant to note that Professor Richard Battin -- a leading astrodynamicist on the design of interplanetary trajectories -- served as a "technical advisor" for Hollister (see page iii Ref. 2). Therefore, the innovation was recognized as new by MIT and by Battin, and that Battin did not invent it.

In 1964, Robert Sohn wrote a paper on missions to Mars using the gravitational field of Venus that was "peer-reviewed" and published in the *Journal of Spacecraft & Rockets.*[3] This journal is one of the most authoritative "peer-reviewed" professional journals in the field of astronautics. In describing the trajectory design technique, Sohn writes:

> "A promising new method for reducing Earth return velocities from Mars stopover or flyby missions is the Venus swingby mode, which utilizes the gravitational field of Venus to decelerate the spacecraft on the return leg, or to accelerate it on the outbound leg, to achieve a more favorable calendar date for return from Mars."

In another "peer-reviewed" paper on missions to Mars using the concept published in another leading professional aerospace journal, the author described the concept by stating:[4]

> "Prospects for a Mars flyby in the 1970s have been brightened considerably by the idea of a "swingby," in which the spacecraft would take advantage of the gravitational attraction of Venus to bend its trajectory toward Mars. In addition, the swingby maneuver would give the spacecraft a free propulsion boost for the last stage of its journey; the craft's acceleration would increase as it whips around Venus. And on the return trip, another swingby would let the Venusian gravity field help slow the spacecraft down from 65,000 fps to a safe reentry velocity of about 45,000 fps."

In 1965, Stanley Ross wrote a comprehensive review paper on the revolutionary impact that the invention would have on the exploration of the Solar System and also described the invention as a new development in space travel.[5] In fact, the invention was regarded as so new and important at that time, that Volume 9 in the AAS Science & Technology Series, where the paper was published (it can be found in almost every science library in the world) was entitled: ***Recent Developments in Space Flight Mechanics***. This book was devoted almost entirely to technical papers on gravity propelled interplanetary space travel and demonstrated that the concept would enable the entire Solar System to be explored with conventional chemical rocket propulsion and relatively small launch vehicles. (Something that I showed was possible on pages 39 and 44 of my 1961 JPL paper that my supervisor Victor Clarke rejected as physically impossible.) Although Ross identified Hollister[2] and Sohn[3] as the inventors, the important point that I want to make here is the fact that it was recognized

as a revolutionary new concept in space travel that would have a profound effect on the exploration of the Solar System. Quoting directly from pages 2 and 3 of his paper, Ross states:[5]

> "The labors of several of my colleagues and myself during the years of 1962 and 1963, and of the group at J.P.L. under Clarke during the same period resulted in the publication of a series of volumes comprising two planetary flight handbooks (1, 2), one devoted to the planning of manned flyby and landing flights to Mars and Venus, the other to unmanned probe missions to these same planets. Together, these handbooks blocked out and charted what we then considered to constitute all worthwhile mission areas for flights to the two nearest planets during the rest of this century. But the picture suddenly changed with the disclosures by Hollister (3) and by Sohn (4), in independent and almost simultaneous works, that the strong synodic fluctuation in mission requirements for fast round trips to Mars could be greatly reduced by employing close approaches to Venus enroute, causing its mass to modify nominally unacceptable trajectories to our favor (Fig. 1). Almost immediately, widespread attention was focused upon the "Venus swingby mission" (as Sohn called it), and results of subsequent studies by Sohn himself and by Deerwester were soon forthcoming."

This paper was also "peer-reviewed" and published in the *Journal of Spacecraft & Rockets* in a paper co-authored with Gillespie.[6] Quoting directly from page 170 of their paper, the authors state:

> Hollister[1] and Sohn,[2] in independent and almost simultaneous works, demonstrated that the strong synodic fluctuation in mission requirements for fast round trips to Mars could be greatly reduced by employing close approaches to Venus enroute, causing its mass to favorably modify nominally unacceptable trajectories (Fig. 1). Almost immediately, widespread attention was focused upon the "Venus swingby mission" (as Sohn called it), and results of subsequent studies by Sohn[3,4] and by Deerwester[5] were soon disclosed."

It is important to note that since all of Sohn's papers were published a year after Hollister's Ph.D. Dissertation, he cannot be identified as a co-inventor with Hollister. But the important fact to be noted here is that the above "peer-reviewed" papers clearly demonstrate that "gravity-assisted" or "Swing-By" trajectories represented a fundamentally new innovation in the design of interplanetary trajectories. **Although the work of Lawden, Crocco, and Hohmann was well known at that time, it was obvious to the authors who wrote the above papers – and to all of the "peer-reviewers" who checked them – that the idea of "gravity-assisted" or "Swing-By" trajectories generated**

by replacing direct-transfer trajectories with indirect trajectories passing one or more intermediate planets was a completely new innovation that was fundamentally different from the work of Lawden, Crocco, and Hohmann.

The proof showing that I invented it is quite simple. Although Hollister was initially credited with having invented the new trajectory design concept, Hollister himself eventually identified me as the originator. In a paper that he co-authored with Menning from Lockheed Sunnyvale, that was "peer-reviewed" and published in the *Journal of Spacecraft & Rockets* in 1970, Hollister and Menning described the innovation within an historical context.[7] Quoting directly from this paper, the authors state:

> "The use of a multiple swingby as part of an interplanetary mission was considered as early as 1925 by Hohmann[1] and 1956 by Crocco.[2] They each proposed interplanetary fly-by missions that would take a vehicle past both Mars and Venus before returning to Earth. Several investigators have subsequently studied this class of mission in more detail.[3-5] It was Minovitch,[6] however, who first recognized the fundamental role which the planetary flyby can play in trajectory design. He saw the planets as sources of free thrust which could be utilized to project a vehicle from one planet to another without the use of fuel."

The paper that Hollister referenced in identifying me as the originator of the concept was my 1961 JPL paper. It is therefore submitted that the above "peer-reviewed" papers published in some of the world's most authoritative professional aerospace journals (together with the expertise of MIT's Department of Aeronautics & Astronautics) prove beyond any reasonable doubt that: (1) "gravity-assisted", "Swing-By," trajectories was a new concept in the design of interplanetary trajectories; and (2) that I invented it.

Therefore, the rules of scientific integrity that research centers operate under in their relationship to their technical staff (i.e., the covenant of ethical behavior) regarding crediting a staff member for making a discovery/invention, require that I be formally and "officially" identified as the inventor from the research institute where I made the discovery -- namely from Caltech's Jet Propulsion Laboratory.

The fact that JPL identified me as the inventor many years ago can also be demonstrated from a paper written by one of it's most prominent former Directors, Dr. William Pickering.[8] Pickering was the Director of JPL from 1957 to 1975 during the time when I was conducting the research, and is one of the most authoritative figures in the history of interplanetary space travel. Quoting directly from page 150 in his paper published in 1970 he states:

> "Six years ago, Minovich (1) first showed that planetary missions could be made more efficient by using near encounters with other

> planets to change the heliocentric trajectories. This so-called gravity assist technique is of great value for journeys beyond the planet Jupiter."

Clearly, this paper by Dr. Pickering, and the other "peer-reviewed" papers cited above, show that there is no doubt about who originated the invention. The "peer-review process" makes it absolutely clear that it was my invention. Therefore, according to the rules of scientific integrity that Caltech is supposed to operate under, I am entitled to receive proper official credit for this invention from Caltech/JPL as in the case of any other invention made by a Caltech/JPL employee. And I am formally requesting this official credit from Caltech/JPL.

The impact that my invention had on the exploration of the Solar System pointed out by Pickering[8] can only be realized by understanding the fundamental technical possibility of exploring most of the Solar System prior to my invention. The most accurate way to obtain this understanding is by reading the technical literature written by the most authoritative leaders in the field prior to the invention. For example, after several years of studying the technical feasibility of exploring the Solar System, Professor Derek Lawden wrote a paper in 1958 on this subject and concluded (page 176 Ref. 9):

> "The periods of transit for transfers between the Earth and the outer planets are so great that the cotangential ellipse is unlikely ever to be employed for this purpose. Instead, non-optimal paths involving larger characteristic velocities but shorter periods of transit will have to be followed and, until much higher exhaust velocities become available (e.g., by the harnessing of nuclear energy for rocket motor drives), such journeys will <u>not be possible</u>."

Lawden was perhaps the world's leading astrodynamicist at that time.

Professor Theodore von Karman, from Caltech, was another leading figure in astronautics and propulsion technology. After studying the high-energy requirements for reaching most of the Solar System with instrumented spacecraft for several years, he concluded in a paper written in 1962 (page 4, Ref. 10) that:

> "It is evident that if we exclude additional propulsion along the trajectory, most of the interplanetary space missions require initial velocities which we are unable to realize by the use of chemical rockets."

Unfortunately, the advanced propulsion systems believed to be absolutely essential for exploring most of the Solar System prior to my invention turned out to be beyond engineering feasibility.[11-13] But most of the Solar System was explored, and it was achieved with ordinary chemical rocket propulsion and relatively small launch vehicles. It was accomplished with the invention of gravity propelled interplanetary space travel. This is what my invention represented and accomplished

-- it opened up the entire Solar System for exploration with instrumented spacecraft. It achieved what was believed to be a physical impossibility. Very few innovations in the history of science made it possible to break through a barrier, believed to be technically impossible to penetrate, and obtain so much fundamentally new scientific information. It is hoped that these statements are not misinterpreted as statements of embellishment, but rather as statements of provable facts.

You should also know that in 1971 JPL's Systems Division (headed by Dr. C.R. Gates) formally approved an award officially granting me recognition for the invention. [14,15] The short citation that was approved by the Systems Division read as follows:[14]

> "For the invention and development of the concept of gravity thrust space flight which formed the basis for the multiplanet missions planned for the seventies. He did the first theoretical and numerical work that demonstrated the many significant advantages of multiplanet travel."

On August 13, 1971 I was notified that the proposed award for the invention was rejected by JPL's "Awards Committee."[16] No explanation was ever given. The award was replaced with NASA's "Exceptional Service Medal" which was the lowest-level award granted by NASA. In essence, the award was granted for numerically computing multiplanetary trajectories involving the inner planets with the implication that it was a previously known concept. No mention was made of: (1) the fact that my invention was so radical when I proposed it in 1961 that it was initially rejected by JPL's trajectory group as impossible; (2) the fact that the concept was fundamentally different from all prior multiplanetary trajectory designs; (3) the fact that my design required a numerical solution to the most famous unsolved problem in celestial mechanics, the Three-Body Problem, which I solved in order to make the concept realizable; (4) the fact that the concept made it possible to carry out a manned mission to Mars using Saturn V launch vehicles and conventional chemical rocket propulsion; (5) the fact that it made it possible to explore the entire Solar System with instrumented spacecraft; (6) the fact that the concept represented a new method for propelling a vehicle through interplanetary space based on gravity propulsion obtained by indirect interplanetary trajectories that was fundamentally different from all the early pioneers based on reaction propulsion and direct-transfer interplanetary trajectories; and (7) the fact that my research was basically a UCLA project and not a JPL project.

I found out later that Victor Clarke -- my 1961 JPL supervisor who believed that the invention was physically impossible after I discovered it and urged him to have it investigated at JPL (see page 76 Ref. 17) -- was attempting to claim credit for it himself with obvious JPL support [18-22] after I took the idea to UCLA and proved that it would lead to a major breakthrough in space travel.[23-29] In retrospect, it is easy to see that Clarke's attempt to take the credit was the real reason why I was refused official credit for the invention in 1971.[16] This is also evident from the fact that after Clarke openly acknowledged the fact that it was my invention,[22] JPL still refused to give me the official credit. (There were other attempts at JPL to give the credit to Homer J. Stewart.[30]) All of these problems were created at JPL in a blatant attempt by Clarke (and others) to claim credit for the invention, and hence destroy the true history behind it (and the history of interplanetary space travel).

After it became evident that these attempts to take credit for the invention would fail, JPL changed the story behind the invention and began putting out information claiming that it was really nothing new after all. And this erroneous information was fed to many authors who published it in many books on the history of space travel. Refs. 31-34 is a very small sample of these publications. I am mentioning these unfortunate facts because in your message to Rex[1] you indicated that it is not JPL's responsibility to "set the record straight." But the evidence clearly shows that the problem with the historical record was created by JPL in the first place. This problem will only continue (and get bigger and more blatant because in order to explain one lie, a bigger lie must be told) if JPL continues to refuse to give me official credit. Although I sincerely appreciated JPL's attempt to give me the credit in their 1989 book which you gave to Sam Dallas,[35] JPL has nevertheless refused to give me the official credit every time I requested it.[36-40]

It is quite possible that if JPL continues to deny me rightful credit for my invention, JPL's scientific credibility will be seriously damaged. (There are a lot of JPL engineers who know that I invented it and cannot understand why JPL is still withholding proper official credit.[41] Dr. Sam Dallas, one of JPL's most reputable astrodynamicists, is only one of many JPL staff members who are concerned with this problem.) Sooner or later these facts will be recognized by someone with authority who cares about scientific integrity and will do something about it. I am not the only one being hurt by all of this. This is what Sam and Rex tried to point out to you during the meeting.

You should also know that the rascals who caused all this trouble might still be at JPL, and might attempt to prevent any paper from being published in the future showing that I invented it. This could easily be accomplished from behind the scenes by simply exerting influence over the "publication committees" of various professional aerospace journals via JPL representatives by attacking my character and calling be a "liar" etc. (Almost every aerospace journal and professional society has a JPL representative on the "publications committee," and an obvious self-interest reason might be to make JPL "look good.") You may think that I am a little paranoid by saying this. However, if you understood what these people have done, and the gross misinformation that they have been putting out about the invention for 35 years you would understand my concern. These people are very determined to prevent JPL and NASA from formally granting the award. They are getting away with it by claiming that it is a very complicated issue[40] when, it reality, it is one of the easiest innovations to understand and identify as new.[42] I am asking for your help, and the help of Dr. Edward Stone and Dr. Mous Chahine (and Caltech as an institution) to prevent this injustice from continuing. I know that you, Dr. Stone, and Dr. Chahine, are not among these rascals, and only want to do what is proper.

The above "peer-reviewed" evidence is more than enough proof that JPL needs to overcome any possible resistance, and grant the award. Surely this is the proper course of action.

I am also enclosing, as a major supplement to this letter, a very detailed technical and historical paper[43] describing the invention that includes copies of the 170 references. It contains much more additional evidence proving that I invented it within a historical setting to show how radical it really was in 1961. To understand the invention, you must understand that it represented a completely different technical methodology for achieving high-speed interplanetary space travel (based on gravity

propulsion using indirect trajectories) than was proposed and taken for granted by all of the early pioneers (based on reaction propulsion using direct-transfer trajectories). JPL has been using my method of space travel to explore most of the Solar System for the past 24 years. It represented the pivotal innovation that it made it possible to break the high-energy barriers of direct-transfer trajectories. The methods laid down by the early pioneers are essentially impossible to use for exploring most of the Solar System. Therefore, the invention was very important in the history of space travel because it literally opened up the entire Solar System to exploration. JPL management should understand this fact, and the history behind it. My paper[43] is designed to describe the invention, both historically and technically, to provide a very clear and technically accurate understanding. It contains information never mentioned in the popular literature. I will be happy to give the paper in a formal presentation to JPL upper management, or to the engineering staff, if you invite me. If you choose not to invite me, the paper should nevertheless be regarded as a presentation to JPL. That is why I am sending it via certified mail. (I am also sending it to other people.) Please make it available to as many JPL managers as possible. There is also the possibility that there are really no rascals left at JPL, but only some managers who honestly don't understand the invention, and don't want to believe that it was actually rejected at JPL as impossible when I invented it. If this is the case, this paper would be very good for informing them about it. It was not easy for me to put it together, and to collect all of the 170 references. Eventually, I hope that you could send it (with all of the enclosures) to JPL's library, or to Caltech's Guggenheim Aeronautical Library, and hence make it available to the engineering staff, and to anyone else. I'm sure that Caltech, NASA, various scientific organizations, aerospace societies, and the authors of scientific and historical books would want to know the true facts behind the invention that broke the classical high-energy barriers to interplanetary space travel and opened up the entire Solar System to exploration with instrumented spacecraft. Since the invention was made at JPL by a Caltech employee, it is something that Caltech should be very proud of. (I would be willing to donate original documents or artifacts for examination and/or display at Caltech or at JPL.)

I am also enclosing technically accurate write-ups describing my invention for the award that, based on the evidence, Caltech/JPL is morally and ethically bound to grant.[44]

If JPL still refuses to grant the award, I will formally request JPL/Caltech to stop claiming that the invention was one of the most important innovations in the history of JPL <u>as is currently being done</u>. The innovation was originally rejected at JPL as physically impossible in 1961 (there are witnesses to prove this fact), and JPL refused my request to initiate the required numerical analysis to investigate it. However, when I took it to UCLA's Department of Mathematics, and requested assistance for a numerical investigation, I received a great deal of support. UCLA's entire computing facility that included an IBM 7090 computer (the largest commercial computer in the world at that time) was placed at my disposal.[23] Moreover, UCLA's support was significantly increased in early April 1962 when they granted me special "stand-by" access to the computer without any time limitations[24] -- and this UCLA support continued through September 1964. This is the real story behind the invention that the American people have a right to know. It was not a "JPL innovation" for the simple reason that after I invented it in 1961 (completely separate from any JPL work assignment), JPL rejected it and refused to conduct any investigation. It can therefore be properly considered to be a UCLA innovation because they accepted it and paid all the bills to support the

required numerical investigation on their 7090 computer. The only reason why I came to JPL in June 1962 was to increase my UCLA numerical investigation because I believed that my method for exploring the Solar System would be much easier than the method proposed by the early pioneers, which it was. But the sad thing was that, aside from all of the missions that resulted from it, it only resulted in advancing the careers of certain "professional astrodynamicists," who then turned around and made it impossible for me to receive proper recognition for it later because it would expose this fact. Had I known this would happen in June 1962, and that Clarke was capable of doing what he did, I would have never come to JPL to use their computers. I already had access to a computer and I could have easily published all of my results through UCLA. But I truly hope that JPL will do the proper thing and finally give me the official recognition that is long overdue.

In closing, I want to thank you again for the meeting with Sam and Rex. They have worked very hard to help me in this effort to obtain formal JPL recognition for my invention. Not so much for me personally, but rather for JPL's scientific integrity, and for the integrity of the technical history behind the development of interplanetary space travel in which we all participated.

Sincerely,

michael minovitch

Dr. Michael A. Minovitch

P.S. I can produce legal affidavits that prove certain officials at JPL destroyed all of my computer output beginning from January 1962 that was moved for storage to the basement in building 180 under JPL supervision after I temporarily left to continue my graduate studies at UC Berkeley in September 1964. This included the output from the UCLA computer that was so much that, by May 1962, required a JPL delivery truck to transport it from UCLA to JPL.[45] Many FORTRAN gravity propelled trajectory programs, listings of program modifications and the efforts to debug them, notes from many computer runs, and many drawings of gravity propelled trajectories through the Solar System were also destroyed. The output that was destroyed represented almost all of the combined output from the UCLA and JPL computers using about 1,000 hours of computer time on IBM 7090 and 7094 main frame computers accumulated over a period of two and one-half years. This is significant because it contained the hard evidence proving that I was trying to numerically calculate gravity propelled trajectories having encounter sequences that included: Earth-Jupiter-Saturn-Uranus-Neptune, Earth-Jupiter-Saturn-Pluto, Earth-Jupiter-Saturn-Uranus, and Earth-Jupiter-Saturn-Neptune, as well as many others involving the outer planets starting with very low launch energy Earth-Venus-Jupiter, Earth-Venus-Earth-Jupiter, and Earth-Venus-Mars-Earth-Jupiter initial legs. If you read page 39 of my 1961 paper (see page 11 Ref. 43), you will notice that I designed the initial gravity propelled trajectory to the outer planets with an Earth-Venus-Mars-Earth trajectory to accumulate sufficient orbital energy to reach the outer planets and thus achieve space travel throughout the entire Solar System using an amount of rocket propulsion that is only required for reaching Venus. At that time, the possibility of exploring most of the planets in the Solar System with only one vehicle using only that amount of launch energy required for reaching Venus was considered to be an absolute physical

impossibility. This paper was not destroyed and stands as prima-facie evidence to support my claims to my invention.[46]

If there is any doubt about the authenticity of any of the UCLA documents enclosed herein (or in Ref. 43), they can be verified by contacting Professor Michael Melkanoff through UCLA's Department of Computer Science. Melkanoff became Chief of Computer Operations in December 1962 and gave me copies of the documents in 1974.[47,48] I believe that Professor Melkanoff retired from UCLA in 1994. If anyone wishes independent verification of the FORTRAN listing of the computer code for my gravity propelled trajectory program, or a description of its operation, they could call Dr. Lowell Wood at the Lawrence Livermore Laboratory. I wrote all of the programs and key-punched the entire 1960-1980 planetary ephemeris for all nine planets myself. Lowell helped me debug the program several times in early 1962. (But it was improved many times.) If anyone wishes independent verification of any other document enclosed herein, or cited in the two IAF papers describing the invention,[49,50] this can be arranged

cc: Dr. Edward Stone, Dr. Mous Chahine

Enclosures (50)

1. Communication from Larry Dumas (JPL Deputy Director) to Sam Dallas and Rex Ridenoure, Sept. 5, 1997.

2. Hollister, W.M., *The Mission For A Manned Expedition To Mars*, Ph.D. Dissertation, MIT (Department of Aeronautics & Astronautics), May 1963.

3. Sohn, R.L., "Venus Swingby Mode for Manned Mars Missions," *Journal of Spacecraft & Rockets*, Vol. 1, No. 5, Sept. - Oct. 1964, pp. 565-567.

4. "Beyond Apollo: Lunar And Planetary Missions," *Space/Aeronautics*, Oct. 1965, pp. 69-75.

5. Ross, S., "Trajectory Design For Planetary Mission Analysis," AAS/AAAS Special Astronautics Symposium, RECENT DEVELOPMENTS IN SPACE FLIGHT MECHANICS, December 29, 1965, Berkeley, California, AAS Paper No. 65-130, pp. 2,3. (Also in *Recent Developments in Space Flight Mechanics*, AAS Science & Technology Series Vol. 9, 1966, pp. 3-43.)

6. Gillespie, R.W. and Ross, S., "The Venus Swingby Mission Mode And Its Role In The Manned Exploration Of Mars," *Journal of Spacecraft & Rockets*, Vol. 4, No. 2, Feb. 1967, pp. 170-175.

7. Hollister, W.M. and Menning, M.D., "Periodic Swing-By Orbits between Earth and Venus," *Journal of Spacecraft and Rockets*, Vol. 7, No. 10, October 1970, pp. 1193-1199.

8. Pickering, W.H., "The Grand Tour", *American Scientist*, Vol. 58, March/April 1970, pp. 148-155.

9. Lawden, D.F., "Interplanetary Orbits," Chapter 9 in *Space Research and Exploration*, ed. D.R. Bates, William Sloane Associates, New York, 1958, pp. 174-175.

10. Von Karman, T., "Introductory Remarks On Space Propulsion Problems," in *Advances In Astronautical Propulsion*, Casci, C. (ed), Pergamon Press, New York, 1962, pp. 3-10.

11. Yaffee, M.L., "Electric Rocket Program Being Reshaped," *Space Technology International*, April 1964, pp. 14-19.

12. "Nuclear Rockets: Flight Systems Deferred," *Spaceflight* 1964, pp. 93-94.

13. "Nuclear Flight Programs Canceled as President Trims FY'65 Budget," *Space Technology International*, 1964, p.24.

14. Gates, C.R., Proposed Citation: NASA EXCEPTIONAL SCIENTIFIC ACHIEVEMENT AWARD - 1971.

15. Minovitch, M.A. "NASA Exceptional Performance Award," JPL Interoffice Memorandum 393.1-213, August 11, 1971.

16. Bourke, R., Directive to Minovitch stating that he will not be given the award for the invention because it was "not considered appropriate for the awards committee," JPL IOM, August 13, 1971.

17. Reichhardt, T., "Gravity's Overdrive," *Air and Space Smithsonian*, Vol. 8, No. 6, February/March 1994, p. 76.

18. "Mariner-Venus '73 Flight Genesis," NASA News Release No. 70-112, July 5, 1970.

19. Parker, P.J., "Grand Tour Spacecraft Computer," *Spaceflight* (British Interplanetary Society) Vol. 13, No.3, March 1971, pp. 88,120.

20. "Mariner 10 En Route to Mercury--Continues Query of Venus," *Mariner Venus/Mercury 1973 Status Bulletin*, Jet Propulsion Laboratory, California Institute of Technology, Bulletin No. 18, Feb. 6, 1974. (Slingshot Technique Sound, *NASA Activities*, Jan. 15, 1975.)

21. Letter from Minovitch to Clarke, June 10, 1974.

22. Letter from Clarke to Hetherington, July 22, 1974.

23. "Notice of Approval," Project No. MA-11, UCLA Computing Facility, Jan. 18, 1962.

24. Minovich, M.A., "Request For Access to UCLA Computing Facility," to conduct numerical research on "A Method for Determining Interplanetary Free-Fall Reconnaissance Trajectories," without time limitations. Request approved by Frederick Hollander (Chief of Machine Operations), April 2, 1962 with Research Project No. CF-09.

25. Minovitch's UCLA gravity propelled trajectory program, Job No. MA-11, March 1962.

26. Planetary configuration diagrams of the Solar System showing the relative positions of all the planets at one-year time intervals for the time period Jan. 1, 1965 - Jan, 1, 1981. These diagrams were used to identify viable planetary encounter sequences (without retrograde legs) for numerical computation with the computer program. (From Minovitch's UCLA Research Notebook, Feb., 1962.)

27. Announcement of seminars on multiplanetary gravity propelled space travel given by Minovitch to JPL Section 312 Engineers (Systems Analysis Section), Feb. 1963.

28. Letter from Dr. Franklin D. Murphy (UCLA Chancellor) to Minovich, March 20, 1963.

29. Minovitch, M.A., "The Determination and Potentialities of Advanced Free-Fall Interplanetary Trajectories," *Proceedings of the First Graduate Academy of the University of California*, April 6-9, 1963, pp. 93-116.

30. Bane, D. "First Stop: Jupiter," *Los Angeles Herald-Examiner,* Sept. 10, 1969, P. A-12.

31. Dunne, J.A. and Burgess, E., *The Voyage of Mariner 10: Mission to Venus and Mercury*, Jet Propulsion Laboratory, NASA SP-424, 1978, pp. 11-14 and 207, 212.

32. Murray, B. And Burgess, E., *Flight to Mercury*, Columbia University Press, New York, 1977, pp. 11,12.

33. Powers, R.M., *Planetary Encounters*, Stackpole Books, 1979, p. 70.

34. Kerrod, R. *The Journeys of Voyager: NASA Reaches For The Planets*, Mallard Press, London, 1990, pp. 8, 80.

35. "Slingshot Magic" Chapter 7 in, *The Voyager Neptune Travel Guide*, (ed. Charles Kohlhase) JPL Publication 89-24, June 1, 1989, pp. 103-109.

36. Letter from Minovitch to Kohlhase, Oct. 30, 1989.

37. Letter from Minovitch to Kohlhase, Feb. 20, 1990.

38. Letter from Minovitch to Kohlhase, Oct. 25, 1990.

39. Letter from Minovitch to Kohlhase, Sept. 4, 1996.

40. Letter from Kohlhase to Minovitch, September 23, 1996.

41. Letter from Professor Broucke to Rex Ridenoure, November 20, 1990.

42. "Proof Showing that Dr. Michael A. Minovitch Invented "Gravity-Assisted Trajectories" and what the Invention Represented"

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