

# MEASUREMENTS OF THE EARTH'S TOTAL MAGNETIC FIELD AND ITS VARIATIONS AT A SITE CLOSE TO THE BRAZILIAN ANOMALY

RESEARCH PROPOSAL LAFE-5



SUBMITTED BY THE  
COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS — CNAE  
TO  
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES — AFCRL  
OFFICE OF AEROSPACE RESEARCH — OAR  
THROUGH THE \_\_\_\_\_  
U. S. REGIONAL SCIENCE OFFICE FOR LATIN-AMERICA

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**Comissão**  
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**Atividades**  
**E**  
**Espaciais**

SÃO JOSÉ DOS CAMPOS  
SÃO PAULO — BRASIL  
DECEMBER 1963



PRESIDÊNCIA DA REPÚBLICA  
CONSELHO NACIONAL DE PESQUISAS  
COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS  
S. José dos Campos, S. P. - Brasil

22085

C. 303-DC/63  
São José dos Campos,  
December 1963

Lt. Col. Charles J. Lyness  
U. S. Regional Science Office  
LAOAR  
Embaixada dos Estados Unidos  
da América do Norte  
Caixa postal 699  
Rio de Janeiro - GB

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Dear Col. Lyness:

Through this letter and enclosures we are submitting to AFCRL through your Office a proposal for a Cooperative Program for Magnetic Measurements.

We have maintained, as you know, some correspondence with Dr. Robert O. Hutchinson, Acting Chief, Geomagnetism Branch, Space Physics Laboratory of AFCRL. We understand that the proposal which follows is to be the basis for a very low cost research contract between AFCRL and the Brazilian National Commission for Space Activities, as mentioned in the enclosed letters from Dr. Hutchinson's Office. Also, we want to let you know that we are in agreement with item 4 of the last mentioned letter of 16 July 1963, reference CRFG/Mr. Hutchinson/3212.

Presently CNAE is going through some reorganizational phase. Before the end of this month the Commission with its Headquarters in Rio is going to become a permanent branch of the National Research Council and the facilities at São José dos Campos are going to be called "Laboratório de Física Espacial" (Space Physics Laboratory) of CNAE. It is understood that I will be appointed Director of the Laboratory besides being one of the members of the Executive Group of CNAE. Prof. Athos da Silveira Ramos will continue as the Chairman of CNAE. The reorganization mentioned above has been the reason for the delaying in submitting this proposal. As Director of the Laboratory, which is a non-profit organization, I will be authorized to negotiate and sign grants or contracts of research.

This proposal has not been submitted to any other organization.

FM/bdr

Sincerely yours  
*F. de Mendonça*  
Fernando de Mendonça, PhD  
Scientific Director

HEADQUARTERS  
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES  
OFFICE OF AEROSPACE RESEARCH  
UNITED STATES AIR FORCE  
LAURENCE G. HANSCOM FIELD      BEDFORD, MASSACHUSETTS

REPLY TO  
ATTN OF:

CRFG/Mr. Hutchinson/3212

16 July 1963

SUBJECT:

Cooperative Program for Magnetic Measurements

TO:

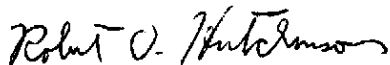
Dr. Fernando de Mendonca  
Scientific Director,  
National Commission for Space Activities  
Sao Jose dos Campos  
Brazil, South America

Dear Doctor Mendonca

1. A copy of your letter of 4 April 1963 to Dr. Sam Silverman expressing a strong need for a total field magnetometer has been forwarded to this branch for possible action.
2. We have a Varian, Model 4900, proton free precession ground station magnetometer with strip chart recording available for long term operation and a Varian rubidium vapor ground station unit that could be utilized for special events of only a few months duration. Both of these units are adaptable to digital outputs and printed displays of various forms.
3. We believe that there is considerable justification for such instrumentation in South America, particularly so at S. J. Campos and would like to suggest an integrated cooperative program whereby such absolute instrumentation could be made available to your activity and in return certain data would be collected and sent to us. This program would take the form of a zero or very low cost research and development contract between AFCRL and the National Commission for Space Activities.
4. AFCRL would furnish you certain specific instrumentation, spare parts, accessories, and recording paper and the opportunity to use the collected data in any responsible manner suited to your program of studies and you in return would collect, catalogue, label, and store this data, making sections of it available to AFCRL as requested.

5. If such a program interests you and your colleagues I would be very pleased to hear from you soon.

Sincerely



ROBERT O. HUTCHINSON  
Acting Chief, Geomagnetism Branch  
Space Physics Laboratory

HEADQUARTERS  
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES  
OFFICE OF AEROSPACE RESEARCH  
UNITED STATES AIR FORCE  
LAURENCE G. HANSCOM FIELD      BEDFORD, MASSACHUSETTS

REPLY TO  
ATTN OF: CRFG/Mr. Shuman/3214

4 September 1963

SUBJECT: Cooperative Program for Magnetic Measurements

TO: Dr. Fernando de Mendonca  
Scientific Director,  
National Commission for Space Activities  
Sao Jose dos Campos  
Brazil, South America

Dear Doctor Mendonca

1. In reply to your letter of 5 August 1963 concerning data sheets for the proton precession magnetometer, I am sorry that none are available. However, the following information may be useful. The magnetometer operates on about 700 watts of 110 v. current with a polarize-read cycle of 3 seconds each. Extremely pure distilled water (impurities of less than 1 part in  $3 \times 10^6$ ) is used as the proton source with a polarizing current of 7 amps. This will generate a sizeable disturbance field to any other magnetic sensors in the immediate vicinity. The output sensitivity of the proton precession magnetometer is 23.4874 gammas per cycle. The output frequency is counted against an internally generated 500 Kc standard obtained by multiplying a 100Kc crystal signal by five. Accuracy of the total intensity to within 0.1 gamma is thus possible, but since only a single reading is obtained once every 6 seconds its usefulness in measuring micropulsations is doubtful.

2. In order to establish a formal channel for the transfer of the equipment, I would suggest a proposal on your part submitted to AFCRL via the office of Lt. Col. Charles J. Lyness at LAOAR. Such a proposal for a program of geomagnetic measurements could be a basis for a zero or very low cost research contract between AFCRL and the National Commission for Space Activities, with the ground station magnetometer to be sent as government furnished equipment.

Sincerely

*for* *B. M. Shuman*  
ROBERT O. HUTCHINSON  
Acting Chief, Geomagnetism Branch  
Space Physics Laboratory

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The objective of the research program of the present proposal is to provide elements of study of phenomena related to geomagnetism. Thus, we intent to complement ionospheric measurements made at this laboratory with geomagnetic field measurements made on the ground and with satellites.

We also believe that, even if it were not for the ionospheric measurements, it would still be justifiable to establish a magnetometric station on this site (São José dos Campos) in view of its geographic position being at the center of the called Geomagnetic Brazilian Anomaly as shown in Fig. 1. It should be called attention also to the fact that the number of stations where magnetic field measurements are made in the northern hemisphere is a region of almost 10:1 in relation to the number of stations in the southern hemisphere.

Last year's International Symposium on Equatorial Aeronomy, held in Peru (with sponsorship of AFCRL and others) recommended among other things that additional magnetic stations should be established at selected sites.

We intend to start the measurements as soon as possible, in order to get the full span of the IQSY, which extends from January 1964 through December 1965.

We also desire to continue the measurements after 1965, while the sun becomes more and more active.

Since we have interest in micropulsations studies we would prefer a rubidium vapor magnetometer. However, if not possible, we could use a proton free precession magnetometer regularly in São José dos Campos and apply for a loan of the rubidium vapor for a period of six months at the time of our rocket soundings at the magnetic equator (Natal) during the IQSY.

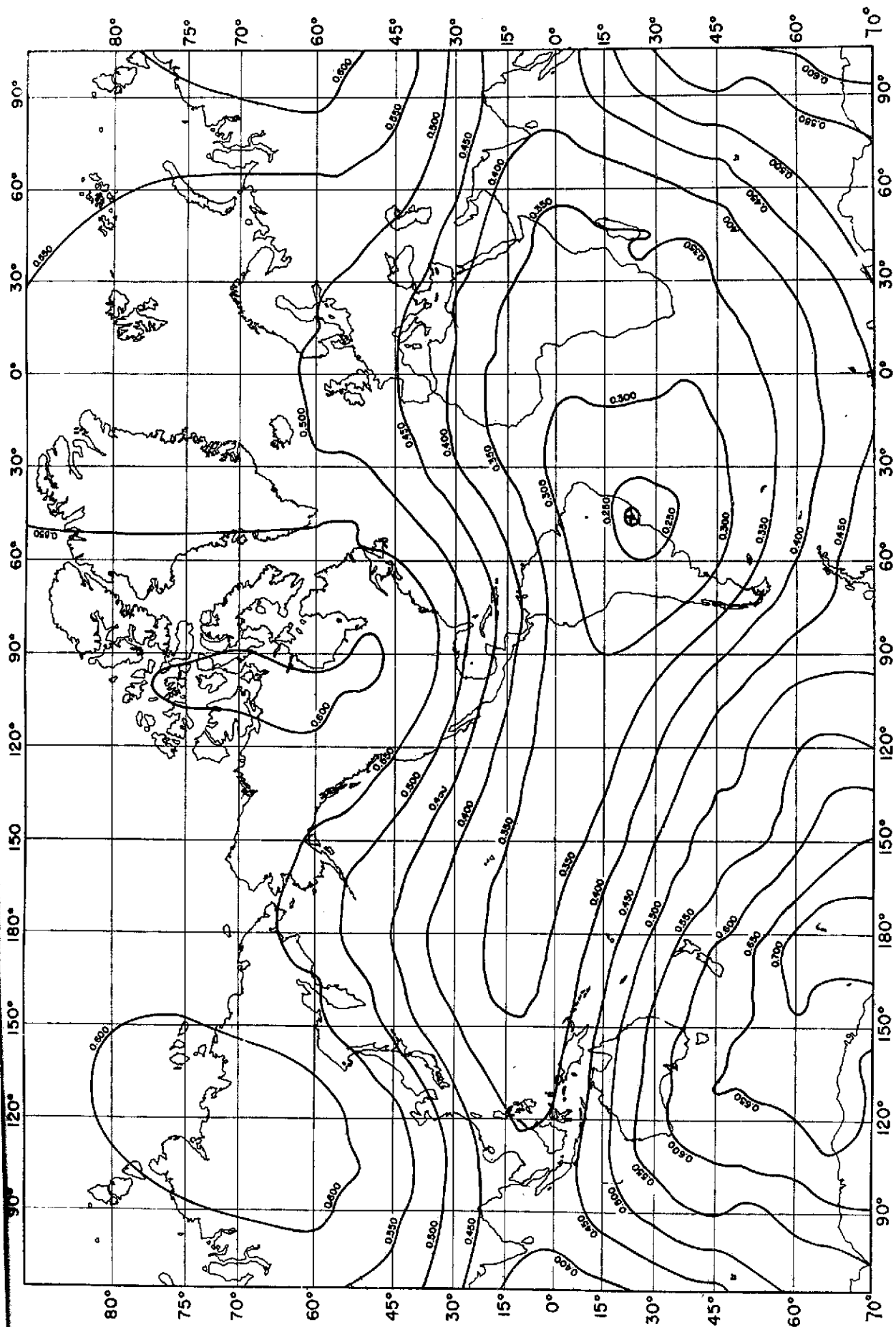


Fig. 1 The Total Intensity (F) of the Earth's Magnetic Field, 1955  
 (from Hydrographic Office Chart)



### GRANTEE'S FACILITIES

The Comissão Nacional de Atividades Espaciais (CNAE), which is under the Brazilian National Research Council, has established a non-profit research center (Ionosphere and Space Physics Laboratory) near São José dos Campos (São Paulo) where the principal interest lie within the field of research in radiophysics and space science. CNAE's laboratory is a new institution which so far has started the following research program:

a) Observation of atmospheric noise in various frequencies with U. S. National Bureau of Standards sponsorships;

b) Observation of solar noise in various frequencies by means of a sweep-frequency receiver (with Carnegie Institution equipment);

c) Studies on the ionospheric electron content and its variations (diurnal, transequatorial, through the Brazilian anomaly, etc.) from satellites observations (NASA loaned equipment);

d) Studies on the ionospheric absorption with riometer (AFCRL equipment through Stanford Research Institute);

e) VLF propagation problems.

In a near future (a few months) it is intended to enlarge the topics of research to include:

i) Ionosounding (vertical continuous scanning frequency and step-sounding);

ii) Magnetometry (protons precession and/or rubidium vapor magnetometers) by means of the present proposal;

iii) Solar radioastronomy;

iv) Around-the-world radio propagation studies (Stanford - AFCRL).

CNAE's laboratory in São José dos Campos has also the active cooperation of the personnel and can make use of the facilities of the near by Instituto Tecnológico de Aeronáutica, which is a government sponsored school of Engineering with undergraduate and graduate courses in electronics, mechanics and aeronautics. This school has over one hundred professors and assistants and about five hundred students.

## BIOGRAPHIC INFORMATIONS OF THE INVESTIGATORS

### a) FERNANDO DE MENDONÇA

Graduated from the Brazilian Air Force Academy in 1953. Studied engineering (5 years courses majoring in electronics) at the Instituto Tecnológico de Aeronáutica (1954-1958) receiving the degree "Engenheiro de Eletrônica" with a "Summa cum Laude". Did postgraduate work at Stanford University from March 1959 receiving the PhD degree (December 1961), with dissertation on "Ionospheric Electron Content and Variations Measured by Doppler Shifts in Satellite Transmissions". From January through December 1962 was a post doctoral researcher at the Radioscience Laboratory at Stanford University (California) and simultaneously represented CNAE in the United States. Since January 1963 he has been the Scientific Director of CNAE. Dr. Mendonça is a full member of American Geophysical Union, Institute of Electrical and Electronics Engineers, Society of the Sigma

#### List of publications in learned journals and reports:

- 1958 - "Minitarck Station Report - ITA", in coauthorship with J. A. M. Coutinho;
- 1960 - "Some Characteristics of the Signal Received from 1958  $\delta$  2", Dec. issue of the Proc. of the IRE; coauthors: O. K. Garriott and O. G. Villard Jr.;
- 1961 - "Ionospheric Electron Content - Report nº 2-RsL" - Prepared under a grant from the National Aeronautics and Space Administration (PhD dissertation);
- 1962 - (a) - "Ionospheric Electron Calculate by a Hybrid Faraday-Doppler Technique"; Journal of Atmospheric and Terrestrial Physics, Vol. 24, April; coauthor: O. K. Garriott;
- 1962 - (b) - "The Effect of the Earth's Magnetic Field on Measurement of the Doppler Shift of Satellite Radio Transmissions"; Journal of Geophysical Research, Vol. 67, May; coauthor: O. K. Garriott;
- 1962 - (c) - "Ionospheric Electron Content and Variations Measured by Doppler Shift in Satellite Transmissions"; Journal of Geophysical Research, Vol. 67, June;
- 1962 - (d) - "Ionospheric Studies with the Differential Doppler Technique"; Tech. Report nº 3-RsL - Stanford University, June; and "Radio Astronomical and Satellite and Studies of Atmosphere"; edited by Jules Aarons, North-Holland Publishing Co., 1963;
- 1963 - (a) - "A comparison of methods used for obtaining electron content from satellite observations"; CNAE Tech. Report nº 1 and also in the Sept. 1, 1963 issue of J. G. R.; coauthor: O. K. Garriott;
- 1963 - (b) - "Latitudinal variation of the ionospheric electron content through the equatorial anomaly", in preparation; CNAE Tech. Report nº 3.

b) JOSÉ PANTUSO SUDANO

José Pantuso Sudano, 29 years old, was born in the state of Minas Gerais, Brasil, and holds a Bachelor's Degree in Mathematics and Physics from the University of Minas Gerais.

Mr. Pantuso spent one year in U. S. A. in a program of Science Education and has been an instructor of Physics at Instituto Tecnológico de Aeronáutica since February 1962. Since March 1963, he has engaged in graduate level research at CNAE's laboratory with the objective of obtaining his Master's Degree at ITA.

His special field of interest include Sun-Earth relationship with emphasis in magnetism.

COST ESTIMATE FOR THE FIRST YEAR  
(U. S. DOLLARS)

<u>Salaries</u>	<u>CNAE</u>	<u>OAR</u>
Dr. F. de Mendonça (15% time).....	450.00	none
J. P. Sudano (100% time).....	2 400.00	none
Senior student (20% time).....	240.00	none
 <u>Equipment (G. F. E.)</u>		
Complete Magnetometer System		
Varian 4 936 (Rubidium vapor).....	-	10 600.00
or		
Varian 4 900 (Proton precession) ....	-	(?)
Voltmeter HP-410C .....	-	300.00
Amplifier HP-466A .....	-	165.00
 <u>Expendable Supplies and Equipments</u>		
Chart paper, IBM cards, transistors, etc.	100.00	350.00
Publication cost (reports, data summaries)	200.00	300.00
Books and journals .....	-	200.00
Housing and installation of equipment....	3 000.00	none
Overhead.....	500.00	none
Cost-first year .....	6 890.00	11 915.00
2nd year .....	3 890.00	850.00
Total cost for two years.....	<u>10 780.00</u>	<u>12 765.00</u>

### RELATED WORKS

Akasofu, S.I., S. Chapman, and D. Venkatesan - "The Main Phase of Great Magnetic Storms" - JGR, Vol. 68, nr 11, June 1, 1963;

Allredge, L.R., G.D. van Voorhis, and T.M. Davis - "A Magnetic Profile around the World" - JGR, Vol. 68, nr 12, June 15, 1963;

Barbier, D., R. Benoit, K.G. Eudden, J.W. Chamberlain, S. Chapman, J.F. Denisse, J.W. Dungey, R. Gallet, G.J. F. MacDonald, and M. Nicolet - "Geophysics the earth's environment Cours donnés a l'école d'été de Physique Theorique de l'Université de Grenoble" - Gordon and Breach, Editor;

Berger, S. - "Giant pulsations in the magnetic field and pulsating Aurora" - Planetary and Space Science, Vol. 11, nr 7, July 1963;

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Chapman, S., and J. Bartels - "Geomagnetism" - 2 vols. (Oxford: Clarendon Press);

Cohen, Robert - "International Symposium on Equatorial Aeronomy" - JGR, Vol. 68, nr 9, May 1, 1963;

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Dungey, J.W. - "Interactions of solar plasma with the geomagnetic field" - Planetary and Space Science, Vol. 10, 1963;

Dungey, J.W. - "Cosmic Electrodynamics" - Cambridge University Press;

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Heppner, J.P., N.F. Ness, C.S. Scarce, and T. L. Skillman - "Explorer 10 Magnetic Field Measurements" - JGR, Vol. 68, nr 1, January 1, 1963;

Hines, C.O. - "The energization of plasma in the magnetosphere: Hydromagnetic and particle - drift approaches" - Planetary and Space Science, Vol. 10, 1963;

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MacDonald, Norman J., and Fred Ward - "The prediction of Geomagnetic Disturbances Indices" - JGR, Vol. 68, nr 11, June 1, 1963;

Mieghem, V. - "Resultats des Observations du Champ Magnetique Terrestre en 1962" - Centre de Physique du Globe - Institut Royal Meterologique de Belgique;

Namikawa, T., T. Okuzawa, and T. Kitamura - "On the propagation of weak Hydromagnetic shock waves in the Exosphere and the sudden commencement of Geomagnetic Storm" - Part I - Fast Shock. SSC, Onset Time at high latitudes - Report of Ionosphere and Space Research in Japan, Vol. XVII, nr 1, March 1963;

Ohshio, M., N. Fukushima, and T. Nagata - "Solar Flare Effect on Geomagnetic Variation" - Report of Ionosphere and Space Research in Japan, Vol. XVII, nr 2, 1963;

Onwumechilli, Agodi - "Lunar effect on the diurnal variation of the geomagnetic horizontal field near the magnetic equator" - Journal of Atm. and Terrestrial Physics, Vol. 25, nr 2, Feb. 1963;

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Rishbeth, H. - "Ionospheric storms and the Morphology of Magnetic Disturbances" - Planetary and Space Science, Vol. II, January 1963;

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Vestine, E. H., I. Lange, L. Laporte, and W. E. Scott - "The Geomagnetic Field, Its Description and Analysis" - Carnegie Institution of Washington Publications 580 - Washington, D. C., 1959.