THE UNIVERSITY MUSEUM • UNIVERSITY OF PENNSYLVANIA
33rd & SPRUCE STREETS • PHILADELPHIA 4, PENNSYLVANIA

Applied Science Center for Archaeology

Froelich Rainey, Director EVergreen 6-7400 (Area code 215)
Elizabeth K. Ralph, Associate Director
EVergreen 6-0100 Ext. 8158 (Area code 215)
Cable Address "Antique"

January 10, 1974

Mr. C.R. Kraus
Consulting Communications
Engineering Inc.
845 Mount Moro Road
Villanova, Pa. 19085

Dear Mr. Kraus:

Some information about our cesium magnetometer is enclosed.

Please excuse the hand-written note. With the ice storm today, there is a scarcity of secretaries here.

When it is time to discuss the design and construction of two new readouts, Bruce Bevan

and I will be glad to
get together with you
and your engineers, etc.

Sincerely yours,

Elizabeth K. Ralph

C. RAYMOND KRAUS
PRESIDENT

CONSULTING COMMUNICATIONS ENGINEERS, INC. ☐ 845 MOUNT MORO ROAD, VILLANOVA, PENNSYLVANIA 19085 215-525-8445

January 21, 1974

Dr. E. K. Ralph, Associate Director
M A S C A
University Museum
33rd and Spruce Streets
Philadelphia, Pa. 19174

Dear Dr. Ralph:

This proposal letter from Consulting Communications Engineers, Inc. (CCE) to the University Museum has been prepared as a result of a meeting held at the Museum on January 18 to discuss the technical problems relating to modernization of the cesium magnetometer. (Bruce Bevan and E. K. Ralph, of the Museum Staff, and D. G. Kilpatrick and C. R. Kraus of CCE, attended.)

It was concluded that a complete redesign of the magnetometer system was impracticable at this time in view of the magnitude of the work involved. However, it was agreed that many improvements are required including a new readout system, replacement of obsolete and unreliable components and subsystems, and elimination of sources of out of service interruptions experienced in the field.

To determine the extent and preliminary design of the proposed modifications will require detailed testing procedures on the existing system and an intensive review of the electronic design. The work will include a survey of the subsystems and components which are currently available for incorporation in and interfacing with the present system. The modified system must accommodate both types of magnetometers.

The results of this preliminary work effort will be summarized in a report which will cover the estimated cost of the work, the time required to complete it and, where desirable, options to enable the Museum to choose the best arrangement.

Our firm will perform the above services for $1900 and will make the report available before February 6, 1974.

We are much interested in the Museum and would be pleased to be associated with you in this work.

Sincerely yours,

C. Raymond Kraus

crk/pm

C. RAYMOND KRAUS
PRESIDENT

CONSULTING COMMUNICATIONS ENGINEERS, INC. ☐ 845 MOUNT MORO ROAD, VILLANOVA, PENNSYLVANIA 19085 215-525-8445

February 6, 1974

Dr. E. K. Ralph, Associate Director
MASCA
University Museum
University of Pennsylvania
33rd. & Spruce Streets
Philadelphia, Pa. 19174

Dear Dr. Ralph:

As discussed herewith is our report and proposal on the modernization of the cesium vapor magnetometer. If the work is authorized by February 20, 1974, the work can be completed by June 15, 1974.

Our invoice for the work to date is included.

Sincerely yours,

C. Raymond Kraus

crk/pm
Encls.

C. RAYMOND KRAUS
PRESIDENT

CONSULTING COMMUNICATIONS ENGINEERS, INC. ☐ 845 MOUNT MORO ROAD, VILLANOVA, PENNSYLVANIA 19085 215-525-8445

No. 1414

REPORT AND PROPOSAL

MODERNIZATION

CESIUM VAPOR MAGNETOMETERS

FOR

MASCA

UNIVERSITY MUSEUM

PHILADELPHIA, PA.

February 6, 1974

I FOREWORD

This report and proposal for design modifications on cesium vapor magnetometers has been prepared by Consulting Communications Engineers, Inc. (CCE) for the University Museum. The work carried out was in accordance with a letter proposal dated January 21, 1974 and confirming discussions between D. G. Kilpatrick and C. R. Kraus of CCE and Dr. E. K. Ralph and Mr. Bruce Bevan of the University Museum staff. Purchase Order No. 26316 dated January 28, 1974 authorized the work which entailed investigation of proposed modifications for cesium vapor magnetometers.

II OBJECTIVES AND SCOPE OF WORK

The work effort is to determine the extent and preliminary design of the proposed modifications by means of detailed testing on the existing system and an intensive review of the electronic design. The work will include a survey of the subsystems and components which are currently available for incorporation in and interfacing with the present system. The modified system must accommodate both types of magnetometers.

Improvements include a new readout system, replacement of obsolete and unreliable components and subsystems, and elimination of sources of out-of-service interruptions experienced in the field.

Estimated cost of the work, the time required to complete it and, where desirable, options to enable the Museum to choose the best arrangement are given.

III RESULTS OF INVESTIGATION

A. General

Although the findings of the study primarily concern feasibility of improving reliability and the read-out display, other improvements are recommended. This report identifies problem areas and gives approximate costs for modernizing two differential magnetometers.

Liquid-crystal displays have been recently reduced to practical hardware. As much as six months ago it would not have been practical to include liquid crystal displays in this type of instrument. There are several mature display systems to choose from, all with the advantage of maximum readability under high ambient light conditions. For low light levels, a push-button controlled lighting arrangement can be provided illuminating the display either from the front or the back. The Data Technology Corp. display seems suitable to our purposes. A final decision will not be made until the whole area has been examined.

The following Table 1 summarizes the modernization of the equipment including replacement of those subsystems that are obsolete or unreliable. This, in our opinion, is a more practical approach than a complete redesign of the entire magnetometer system and it will be cost effective.

TABLE 1

SUMMARY, MAGNETOMETER MODERNIZATION

Unit	Module or Section	Problem/Solution
SENSOR	Amplifier	Non-interchangeability of sensors (SN. 153 & 197 have low output)/Make all equivalent to SN. 90 & 93
	Voltage Reg/Lamp Osc.	(Efficient/No Change)
	Temperature Control	Possible inefficiency/Further study
BATTERY (2 Units)	Cells	Poor Regulation, Liquid/"Ni-Cad"?
	Mechanical	Fragile, Unprotected/Cases, recable
	Electrical	Choke unprotected/install fuse
READ-OUT (2 Units)	Display	Too dim in high ambient light/Liquid Crystal
	Timer	Needs faster reset/compatible with fast display
	Counters	Least Significant-Always even/new decoder
	Larmor Freq. Inputs	Reliability/See Below
	Larmor Freq. Outputs	Need Mag. B Output/add output
	Connectors	Mechanical damage/new types, relocate
	Power Pack, 5V	Efficient? Reliable? Replace?
	Circuitry Reliability	Schematics incomplete/Document, analyze
	Component Reliability	Obsolescence, wear/replace transistors and electrolytics that are under-rated, replace switches and other mechanical.
	Mechanical	Somewhat fragile (particularly external connectors)/Modify
OPERATING	Manuals	Incomplete/Update and combine with Sensor
	Spares	None/Include components (and PC boards as practical) packed for field use

B. Sensors

The basic problem is the lack of interchangeability caused by a low-level output of the Larmor frequency signal from the sensor units. We see no problem in making all units interchangeable with equivalent outputs. In analyzing the efficiency of the temperature control, there is some question as to the efficiency of using battery energy. This is particularly true at higher battery voltages.

C. Battery

Rechargeable cells should be replaced at three to five year intervals. The present silver-zinc cells have poor voltage regulation. This puts an unnecessary burden on the four voltage regulation subsystems. With recent improvements of sealed nickel-cadmium cells, improved regulation and lowered replacement costs can be achieved. There will be a small weight penalty, chiefly in providing aluminimum protective cases and quick-change connectors for individual cells.

D. Read-Out

As noted earlier, it is practical to go to a liquid crystal display at this time. We would expect no problem in reading this type of display in strong sunlight. It will, of course, be necessary to replace the decoder and driver circuitry and to interface this type of display with the present counter and timer circuitry.

The changes relating to reliability within the read-out unit are summarized in the table. The connector problem can be alleviated, in our opinion, by relocating and using newer styles of "BNC" (Amphenol) connectors and by bonding cables and connectors together with shrinkable Teflon tubing.

E. Operation and Maintenance

Operating, repair, and maintenance instructions are essential to satisfactory field use of the instruments. It is planned to prepare new instructions of such size that they can be stored within the lid or cover of the read-out unit.

F. Spares

Spares should be carefully selected and packed for field use. This is an important phase of the overall job.

IV CONTRACT MATTERS

A. The work outlined will be performed for $22,495. About $5,000 is for material and the remainder design, engineering and technician labor.

The approximate division of the work effort is as follows:

General Design Work	34%
Sensor	16%
Battery	10%
Read-out	26%
Operation Instructions and Spares	14%
	100%

B. Schedule

If work is authorized by February 20, 1974, the work will be completed before June 15, 1974.

C. Payment

Payment will be made within 30 days of completion of work.

UNIVERSITY INTRAMURAL CORRESPONDENCE

MUSEUM

MEMORANDUM

TO: Professor Robert H. Dyson, Jr., Acting Director of the University Museum

FROM: Dr. Elizabeth K. Ralph, Associate Director of MASCA

DATE: February 8, 1974

SUBJECT: Rebuilding of Precision Portable Cesium Magnetometers

In NSF Grant GS 36308 X, $20,000 was budgeted about two years ago for the purchase of two new cesium magnetometer readouts and the purchase of two new cesium sensors (from Varian Associates, the original designers and constructors of this magnetometer in 1964). The sensors, which are standard Varian products, have already been purchased for less than the amount budgeted, namely, $1900 each. However, these new sensors are slightly different (have less gain in the amplifiers) than our original ones supplied with the precision readout, and therefore have to be modified.

On February 17, 1972, Varian Associates sent me a quotation of $70,000 for one new readout and two sensors. More recently two other companies, Geo Metrics and Barringer Research Ltd. have refused to undertake the project (mostly because the sensors are patented by Varian Associates).

Therefore, Bruce Bevan and I contacted Consulting Communications Engineers, Inc. Villanova, Pa. to undertake the construction of two new readouts as well as the revision of the two new sensors. After a meeting with Raymond Kraus, President, and David G. Kilpatrick, Design Engineer, we agreed that it would be more practical to revise and upgrade our present readouts rather than design and construct completely new ones.

For this work and the revision of the sensors, CCE's quotation is $22,495 (copy attached).

In NSF Grant GS - 36308 X, we have $18,700 remaining for the purchase of equipment in the first year (11/15/72 - 11/15/73) and $7900 budgeted for the second year for equipment. Therefore, even though the cost of upgrading the cesium magnetometers is slightly greater than anticipated, we have the funds to pay for it, and we feel that it is essential that they be rebuilt before we travel with them to Iran, Egypt and other distant sites. In recent years breakdowns have been frequent and some replacement parts are now unobtainable.

We are asking for your approval for the modernization of two cesium magnetometer systems.

SUGGESTIONS FOR A NEW

CESIUM MAGNETOMETER

FOR MASCA

The Varian Associates Model 4920 Precision Portable Cesium Magnetometer has been the best magnetometer that has been designed for archaeological prospecting. It is the most sensitive and the most rapid to use for making grids (the Model V-4971 Portable Search Magnetometer with audio readout is faster for line traverses, but much slower for grids due to the necessity of adjusting the dial for each precise reading).

The magnetometer is now almost ten years old, and there is a need to modernize or rebuild the readouts (two identical units). For example, replacement Shelly lights (for the 3-number digital display) are now unobtainable, and they never were satisfactory - in bright sunshine we have to use a long narrow black light shield on the"viewer".

Since Varian has patented the sendors, we plan to continue to use theirs. We have two (#90 and #93) that are ten years old and have an extra amplification stage (see diagram). We have two other standard sensors (#195 and #153) which are newer. If it is possible, it would be best to design a new readout to function with both types.

Present readouts give readings directly in gammas with one sensor with a range switch adjustable from 0.1 γ, 1 γ, 10 γ, to 100 γ. When used in the differential mode with two sensors, sensor "B" becomes the reference oscillator, and in normal earth fields, the maximum sensitivity becomes 0.05 γ although the readings are no longer directly in gammas.

Other thoughts are as follows:

1. Readout: Now Model 49-116
   (a) Somewhat smaller and simplified. For example, the External Synchronization feature is not needed, and possibly other components could be reduced in size or eliminated. Readout now draws 0.6 amps. Less current drain would be desirable. Specific details of these revisions could best be worked out between the engineers at Barringer Research and Beth Ralph.) CCE

and Bruce Bevan.

1. (b) Strain - relieved rugged cable connectors.

2. Batteries: Now seven 4.5 volt Yardney Silvercel, 10 Amp Hours, Rechargeable.
   Strain - relieved rugged cable connectors needed. Total wt. 7 lbs.

3. Cables:
   Also, with strain-relieved rugged connectors.
   Since the cables and, especially, the connectors have been the causes of frequent breakdowns in the field, these would have to be improved before the instruments could be used regularly by archaeologists without the assistance of physical scientists.
   We may have to keep the BNC connectors for the sensors, perhaps with the addition of a strain-relief clamp.

P.S. - Maximum Repetition rate is one second or less with a "memory" to hold the numbers until sensor is moved.

C. RAYMOND KRAUS
PRESIDENT

CONSULTING COMMUNICATIONS ENGINEERS, INC. ☐ 845 MOUNT MORO ROAD, VILLANOVA, PENNSYLVANIA 19085 215-525-8445

June 24, 1974

Dr. Elizabeth K. Ralph, Associate Director
University Museum
University of Pennsylvania
Philadelphia,
Pennsylvania 19174

Dear Dr. Ralph:

I am enclosing a copy of my letter which I am sending to RCA complaining about the miserable job they have done on Liquid Crystal displays.

We are in serious trouble in connection with this job and cannot afford to lose $15,000 or more.

Accordingly, we request earnestly that we be permitted to bill on a time and material basis. We have already expended over $35,000.

Sincerely yours,

C. Raymond Kraus

crk/pm

Encl.

Mtg. 7/24/74
Agreed to pay
xtra #8000 1/1/75

Absorb their costs
Wed - July 17th
Mr. Turnough

C. RAYMOND KRAUS
PRESIDENT

CONSULTING COMMUNICATIONS ENGINEERS, INC. 845 MOUNT MORO ROAD, VILLANOVA, PENNSYLVANIA 19085 215-525-8445

June 24, 1974

Mr. W. C. Hittinger, Executive Vice President
RCA
600 N. Sherman Drive
Indianapolis
Indiana 46201

Dear Bill:

Sorry to bother you, Bill, but I feel that I must bring to your attention the kind of job that RCA is doing in connection with the Liquid Crystal Decoder Driver and the Liquid Crystal Display. As the result of lack of information, inability to find anyone at Somerville who understands the operation, and poor connector design, we stand to lose $15,000 or more on the project involving the modernization of two cesium vapor magnetometers for archeological research at the University of Pennsylvania Museum. The Museum insisted that we take the job on a fixed fee basis and we cannot afford to lose this kind of money on a job.

In the first place we were delayed two months in getting the correct display and driver. The initial shipment was not what we ordered and we had to send it back after much wasted effort. When we finally got the display there was no information on the pin functions available in print for the Driver and we got a lot of inaccurate information from people at Somerville who purported to know. Apparently the Driver - Liquid Crystal is not yet a satisfactory package and the MOS people do not interface satisfactorily with the Liquid Crystal people. We actually designed three separate interfaces for the Driver. We just now discovered that the connectors in the Liquid Crystal Display Unit are poorly designed and unreliable. The connector contact with the unit provides intermittent opens and high resistances. The behavior electrically is most erratic.

It has been a frustrating experience and I am bringing this to your attention since our discussions through our dealer are inadequate to handle the problems. Enclosed is a summary of the problem.

Sincerely yours,

Ray

C. Raymond Kraus

CRK/dv

Encl.

RCA Liquid Crystal Display and MOS Driver

1. Initial shipment of incorrect display and driver. (We ordered by correct code number.)

   Two months delay in securing CD 4056 AE Drive
   CD 4054 AE Driver
   TA 8054R Liquid Crystal Display

2. No definite terminal assignments. Incomplete information circuit diagrams. No data on requirements for input to pins, amplitude and duration of strobe pulse.

3. Contradictions from Somerville. Never could talk to same person. Each technical advisor had a different idea about how the display worked. As a result we designed at least three separate interfaces for driver.

4. There is conflict in information in Data Book and in File No. 635.

5. Opens and high resistances are intermittently encountered - electrically erratic behavior in connector in Display Unit.

MR. DAVID G. KILPATRICK
CONSULTING COMMUNICATIONS ENGINEERS, INC.
845 MOUNT MORO ROAD
VILLANOVA, PA 19085

DEAR DAVE,

HERE IS A COPY OF THE COMPLETE SET OF SCHEMATICS FOR THE VARIAN READOUT AND SENSOR ELECTRONICS. IF THERE ARE SOME ILLEGIBLE AREAS, GIVE ME A CALL AND I'LL SEND OUT THE ORIGINALS.

THE SENSOR THAT YOU HAVE IS NUMBER 93, THE OTHER THREE HERE HAVE SERIAL NUMBERS 90, 153, AND 195. NUMBER 90 AND 93 AS SEEN BY THE SCHEMATICS HAVE A DISCRETE COMPONENT AMPLIFIER AND FURNISH ~~LESS~~ GREATER GAIN THAN THE OTHER TWO WHICH USE AN IC. THEREFORE, THE NEWER SENSORS #153 AND #195 SHOULD HAVE ~~HAVE~~ THEIR CIRCUITS MODIFIED TO INCREASE THE GAIN AND MAKE THEM COMPATIBLE WITH THE OTHER TWO.

THAT WAS A FINE DISCUSSION WE HAD HERE LAST FRIDAY WITH WITH YOU AND RAY. GIVE EITHER ME OR BETH RALPH A CALL WHEN YOU NEED AND FURTHER QUESTIONS ANSWERED.