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Atomic Energy Commission AEC 928/1, 'Visit to Israel by U.M. Staebler and J.W. Croach, Jr.'

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Summary:

Summary of a visit by AEC scientists U. M. Staebler and J. W. Croach, Jr., to nuclear facilities in Israel, including the Dimona reactor.

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June 7, 1961

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ATOMIC ENERGY COMMISSION

VISIT TO ISRAEL BY U. M. STAEBLER AND J. W. CROACH, JR.

Note by the Secretary

1. The General Manager has requested that the attached report be circulated for the information of the Commission.

2. It will be recalled that this item was discussed at the morning meeting on June 2, 1961.

W. B. McCool
Secretary

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6-7-61

VISIT TO ISRAEL

U. M. Staebler - J. W. Croach, Jr.

SUMMARY

We were in Israel from the evening of May 17, 1961 through the morning of May 22, 1961. The visit to the site of the nuclear research center south of Beershoba, near Dimona, took place on Saturday, May 20. This was a holiday and the site was inactive except for the Director and some key technical staff present for the visit. A thorough description of the site was provided and questions were answered freely. However, no written material was handed out, no pictures were permitted, and it was made clear that information regarding the site is considered classified by the Government of Israel.

The visit confirmed that the central feature of the site is to be a heavy water moderated and cooled research reactor of about 26 MW design capacity. The other major nuclear development facilities planned for the site include (a) fuel processing pilot plant, (b) pilot plant for making uranium metal from ore concentrate, (c) hot and cold laboratories for chemistry, analytical chemistry, and metallurgy, (d) waste disposal facility which will also serve to handle radioactive wastes from other parts of the country, and (e) an engineering component development facility.

The nuclear center is the result of studies started in mid-1957. It was conceived as a means for gaining experience in construction of a nuclear facility which would prepare them for nuclear power in the long run. The planned composition of the center is consistent with that objective. Responsibility for design, construction and organization for operation is in the Industrial Group which gets services mainly from the staff of the Ministry of Defence.

Justification for classification of the project is based upon (a) possibility of Arab boycott of suppliers, (b) concern over Arab raids or other actions which might interfere with or stop construction, and (c) desire to limit knowledge of Arabs of their scientific capability. It is expected that classification will be lifted when construction is complete and the site is operating as a development center.

This material contains information affecting the national defense of the United States within the meaning of the espionage laws, Title 18, U.S.C., Sec. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

DISCUSSION

We arrived at Tel Aviv at about 8:15 p.m. on Wednesday, May 17, 1961. We were contacted immediately on deplaning and taken to a private room where we met Dr. Katchalski, Head of the Department of Biophysics of the Weizmann Institute of Science, and Mr. M. Gilboa of the Public Relations Department of the Ministry of Defence. Dr. Katchalski said that the Prime Minister had asked him to greet us. He is one of the scientific advisors to the Prime Minister. Mr. Gilboa became our guide and accompanied us everywhere we went. We stayed at the Accadia Hotel - a resort remote from Tel Aviv. The rooms were in Mr. Gilboa's name.

We asked on the second day if we were to meet Professor Bergman and were advised that he is a public political figure and that such a meeting therefore seemed undesirable in view of the desire to avoid publicity of the visit but might be arranged if we really wanted it. We did not pursue the matter further. The fact that the Atomic Energy Commission is only an advisory group was emphasized on a number of occasions in response to our questions.

A schedule was suggested which we agreed should be satisfactory. It consisted of the following:

Thursday, May 18	(A.M.)	Visit to Swimming Pool Reactor at Nahal Sorek
	(P.M.)	Visit to Weizmann Institute of Science at Rehovoth
	(Evening)	Dr. Katchalski arranged an informal meeting with some of the technical staff
Friday, May 19	(A.M.)	Visit to Technion University at Haifa
	(P.M.)	Returned to hotel via Nazareth and Sea of Gallilee
Saturday, May 20		Visit to Dimona - Dr. Katchalski accompanied us "at the request of the Prime Minister"

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Sunday, May 21, 1961	Visit to Hebrew University at Jerusalem
Monday, May 22, 1961	Departed - 10:30 a.m.

This report covers (1) discussions with Mr. Pratt and his staff at Dimona and (2) the status of the swimming pool reactor at Nahal Sorek. Visits to the other installations were of interest particularly as an aid to obtaining a better understanding of the scientific effort in Israel. Since information on these installations is generally available in published literature, they will not be treated specifically in this report.

DISCUSSIONS WITH MR. PRATT AND STAFF AT NUCLEAR RESEARCH CENTER

We arrived at the reactor site near Dimona about 11:00 a.m. on Saturday, May 20, 1961, after motoring from Tel Aviv. Since this was a holiday the only people at the site were the security guards and those specifically involved in our discussions. We met with the following persons during the course of the day:

Mr. M. Pratt -	Site Director
Mr. Niv -	Architect
Mr. Adar -	Reactor Site Engineer
Dr. Baror -	In Charge of Metallurgy
Mr. Sercussi -	Hot Laboratories
Mr. Geery -	Waste Disposal
Mr. Pazy -	Reactor Physicist
Mr. Duron -	Reactor Engineer

We were greeted very cordially with emphasis that we were the first visitors from outside the country. The ground rules for the visit soon became clear: namely, that all questions would be answered, no written material would be given to us, and no pictures would be allowed. The matter of taking pictures led to some confusion since the initial reaction was that it probably would be all right but as we left for a tour of the site, Mr. Pratt said he had checked the security officer and was sorry to say that pictures would not be permitted. He said he had not been allowed to take any pictures yet.

We were also advised that information on the site was still considered classified by their Government. The reason for this is to avoid allowing the Arabs to get information which might lead to (a) boycott against suppliers, (b) actions such as raids intended to stop or delay construction, and (c) a better appraisal of the technical capability of Israel. It is expected that classification will be lifted when the plant is in operation. This was recognized as unusual in comparison with the U.S. procedures but was described as customary for them because of "being surrounded by enemies very close by."

Mr. Pratt gave the background and history of the project. Planning goes back to 1957. At that time decisions had been made on proceeding (a) with the swimming pool at Nahal Sorek (now in reduced power operation), (b) with the heavy water pilot plant at the Weizmann Institute (now operating mainly as a source of O-18 for research purposes) and (c) with uranium recovery from phosphates (which is being carried out in a pilot plant near Rehovoth with a capacity of 1½ tons of concentrate per year.)

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A three-man committee was appointed by the Prime Minister in mid-1957 to make recommendations regarding a five-year program. The Committee consisted of Professor Bergman, Mr. Pratt, and Dr. Dostroyski. A study was made with the benefit of information obtained by a number of people who were sent to other countries for training and information. A report was submitted in mid-1958 and approved by the Prime Minister by the end of 1958.

The three-man committee became the nucleus of the Industrial Group which was established to design, construct, and organize for operation a nuclear research center. This center was to include a reactor of natural uranium and heavy water along with various laboratories, including hot labs and a transuranium lab.

The early studies of the committee considered were immediate ventures in power reactors. A station consisting of two 70 MWE reactors of the PWR type was studied but found to be too expensive. The committee then considered research reactors and found that building a research reactor could provide experience in essentially all of the problems posed by power reactors. Thus the nuclear research center was conceived as a means for gaining experience in construction of a nuclear facility which would prepare them for nuclear power in the long run.

Natural uranium was selected as fuel for the reactor because of a desire to be able to produce as much as possible within their own borders. Plans for pilot plants for taking ore concentrates to uranium metal and eventually for cladding fuel are consistent with that desire. The pilot plant for Pu separation was said to be based on interest in future use of Pu as power reactor fuel.

Ground breaking took place in 1959. The site proper is about 750 meters square although the fenced area is much larger. The site was studied very carefully with many borings to determine geology and hydrology. Borings were taken every 200 meters with extra borings in areas of key buildings. Even so, problems were encountered with "clay pockets" in laying foundations. Ground water is 80 to 90 meters below the surface and flows to the Dead Sea. Process water for the site will be obtained thru a 1½ meter diameter pipe line coming from the river near Tel Aviv. It was reported to have a capacity of 40,000 gpm. Construction of this line has progressed to Dimona so far.

The site is subject to some seismic activity so the buildings are being built to the "Los Angeles Code", i.e., to withstand acceleration of 0.5 G.

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The Industrial Group gets its services mainly from the operating organization of the Ministry of Defence but it also obtains services (e.g., meteorology) from other agencies.

The eventual size of the operating staff is not definite but in talking of the canteen capacity of 500 it was mentioned that the total staff may be two or three times that. It is expected that many of the engineers now working on design and construction will transfer to the operating staff.

It was noted that the Prime Minister has great interest in establishing a university at Beersheba and of having the nuclear center associated with the university in some way. Strong efforts already are evident to get more professionally trained people to move to the area to help development of the Negev.

The plot plan, status of construction, reactor design, and highlights of other major technical facilities are given in attachments hereto.

The reactor design "is very much influenced by the French El-3.". The nuclear design calculations were done by the French. This reactor occupies a somewhat larger part of the containment vessel than El-3 because it is designed to use natural uranium rather than enriched fuel and because it uses ordinary concrete rather than heavy concrete for shielding.

Attachments:
Approximate Site Plan
Other: 1 thru 5 as
identified

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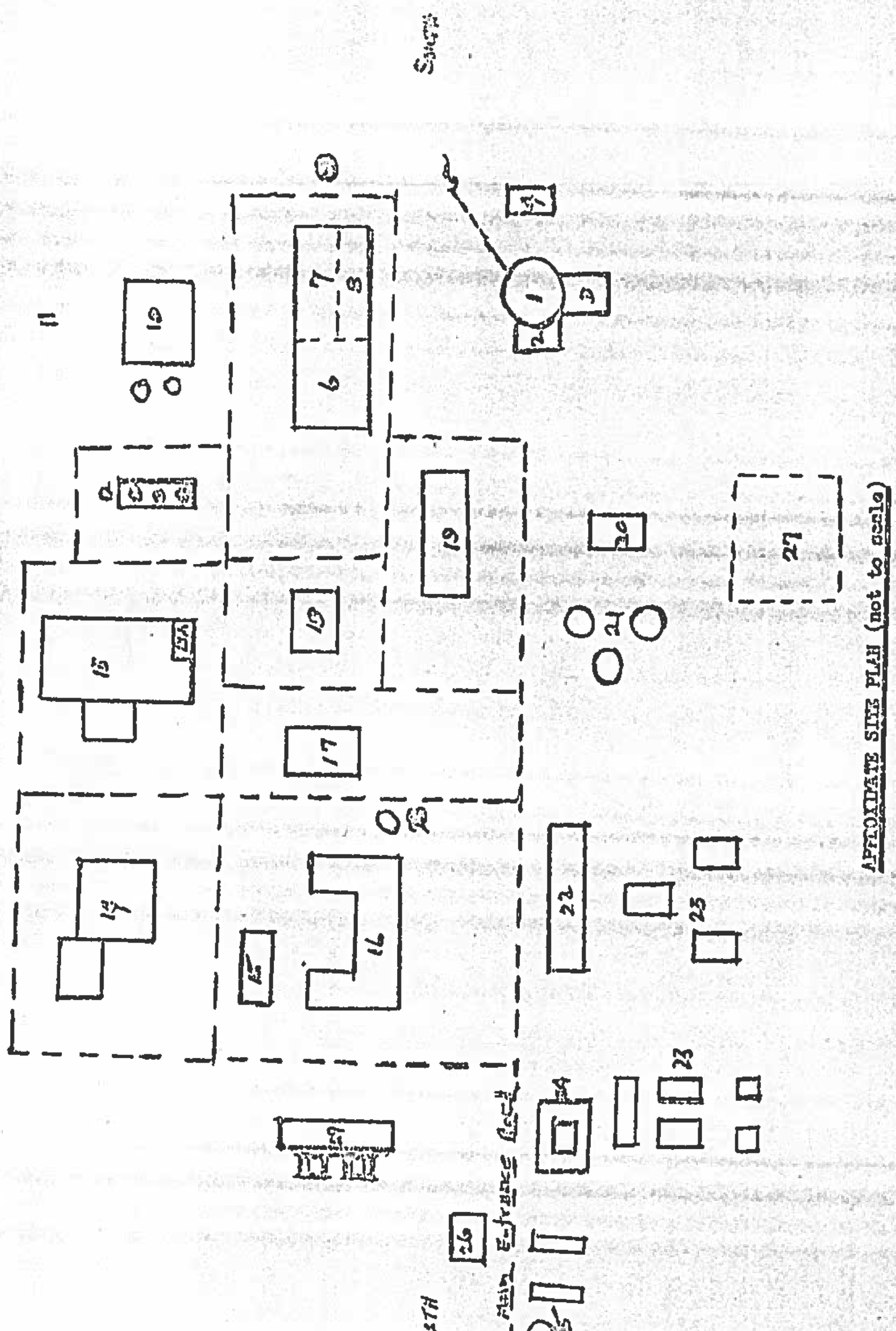

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LEGEND

1. Reactor
2. Control and auxiliary equipment area
3. Cooling pond for irradiated fuel
4. Cooling towers
5. Space for 220 meter neutron chopper
6. Decontamination
7. Filtration equipment
8. Transuranium - process pilot plant
9. Stack
10. Waste disposal
11. Underground tank area for disposal of process wastes
12. Diesel fuel storage
13. Hot laboratories: chemistry, analytical chemistry, and metallurgy

13A. Hot cell

14. Cold laboratories: chemistry, analytical chemistry, and metallurgy
15. Library and documentation
16. Hotel and canteen
17. Technology - engineering components
18. General services
19. Pilot plant for taking uranium concentrate to metal
20. Water treatment
21. Water storage - two for treated water; one for raw water
22. Administration
23. Workshop and stores - also instrument maintenance which is only building of permanent type construction

Attachment 1

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24. Health physics and radiation medicine
25. Guard station and worker check-in
26. Temporary canteen
27. Electrical distribution - 110 KV stepped down to 33 KV - also serves Dimona, Dead Sea, and Copper Works but with priority on expected use of 9,000 KVA.
28. Water tower
29. Hospital

STATUS OF CONSTRUCTION

The administration building is complete and at least partially occupied.

The hotel and canteen building looks complete from the outside but is not yet in use.

The only building in which we observed operating technical equipment is the cold metallurgy laboratory. The rest of the cold laboratories are nearly complete except for installation of equipment.

The external building shell of the hot laboratories is up except for the hot cell which has only part of the floor poured.

The waste disposal building is up but is still very rough on the inside and no process equipment is installed except for two tanks on the north side of the building. Excavations have been made for the deep underground storage tanks in back of the building.

The three water storage tanks are complete but the water treatment building is in early stages of construction.

Electrical distribution, workshop, and stores areas look complete.

The water tower is complete.

The reactor structure is barely complete in external outline.

The reactor concrete shield is about 2/3 complete. The building on the inside is mostly rough concrete.

The stack is barely above ground level, but it will be about 100 meters high when complete.

Status of other buildings varies from early ground preparation to partial construction of building walls.

Plans call for the laboratories to be in operation well ahead of the reactor. The reactor is expected to be completed in 1964. We were told that difficulties were being encountered in welding the calandria and that it was not expected to be delivered to the site for about a year.

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SUMMARY OF REACTOR DESIGN

Power	26 MW thermal
Moderator	D_2O
Coolant	D_2O
Coolant flow	1800 cubic meters per hour
Inlet temperature	40.8°C
Outlet temperature	51.7°C
Velocity	About 4.2 meters/second
Inconel tubes and lining in primary heat exchanger. Standard equipment in secondary heat exchanger system.	
Number of coolant loops	3
Design capacity	13 MW each loop under design conditions - (one spare)
Primary coolant inlet and outlet at bottom of reactor	
Reflector and shielding are air cooled	
Fuel	Natural uranium - probably will be metal alloy with a few percent of molybdenum
Diameter	35.6 mm
Clad	1.5 mm aluminum
Length	5 sections 50 cm long in each element
Amount	166 elements or about 8 tons calculated loading but 180 lattice positions will be available

Attachment 3(1)

EXPERIMENTAL FACILITIES

8 radial holes to calandria

6 ion chamber positions

2 through holes tangential to calandria

1 biological cavity

1 large center tube in reactor core - 145 mm diameter by 3 meters long - estimated flux 5×10^{13} thermal, 3.7×10^{13} fast

9 holes in graphite reflector including one like center hole so that some experiments will be done first at the lower neutron flux

2 pneumatic tubes for short term exposures including one of through tube design

CO_2 supply available for experimental facilities

CONTROL SYSTEM

6 "security rods" of boron carbide powder in stainless steel

11 shim rods of aluminum with boral carbide

2 fine control rods made like the shim rods

PHYSICAL DIMENSIONS

Lattice spacing	13.5 cm hexagonal
Calandria diameter	2.57 meters
Graphite reflector	80 cm thick
Iron thermal shield	20 cm thick
Concrete shield	3.80 meters thick
Containment vessel - diameter	36 meters

GENERAL COMMENT

It is quite possible that after operating experience has been obtained the power level of the reactor can be increased by a factor of the order of two by certain modifications in design and relaxation of some operating conditions. Design conservatism of this order is understandable for a project of this type.

Attachment 3(3)

HIGHLIGHTS ON OTHER TECHNICAL FACILITIES

I. Fuel Processing Pilot Plant

This plant is designed to handle one Kg of irradiated reactor fuel per day. It is based on the well-established Purex process with mixer-settlers as the means of contacting reagents. It is designed to operate on a batch basis for flexibility. The plant is intended to provide experience in fuel processing since they believe that shipping long distances for processing is impractical for nuclear power in the long run. Also, they want enough plutonium to experiment with as a power fuel. This plant does not have sufficient capacity to process all fuel from the reactor unless an average exposure of 26,000 MD/ton is achieved. The probable exposure is 1/10 of that.

II. Waste Disposal

This facility is designed to neutralize and concentrate by evaporation radioactive waste. It is expected to do this as a service for the whole state. It is designed to operate normally with material containing about 10^{-3} micro-curies per cc but can handle more active material for short periods. It is to be equipped with two evaporators each with a capacity of $2\frac{1}{2}$ cubic meters per hour containing up to one or two curies per cubic meter.

III. Hot Cell

The hot cell will be located at one corner of the hot laboratories. It is designed for 10 kilo-curies of activity and will have six manipulators - two at each of three operating positions.

IV. Metallurgical Laboratory (cold)

The only development work in evidence at Dimona was the beginning of fuel element development in the "cold laboratory." Here some equipment was installed and preliminary tests were in progress.

Metallurgical development is being initiated with two objectives: (1) to decide what fuel elements should be used initially in the Dimona reactor and (2) to gain experience in fuel element technology which will ultimately pay off in fuel elements for power reactors. Current work involves the experimental casting of uranium alloy, development of welding techniques for aluminum cap-can closures, hydrostatic cladding of aluminum cans on slugs, evaluation of stability of fuel elements under thermal cycling and development of methods for inspecting quality of fuel elements.

Attachment 4(1)

A few comments on each of these activities follow:

Casting of Uranium Alloys

They hope to dodge the problem of preferred orientation by restricting themselves to cast structures. Casting so far has been on a small laboratory scale, mainly to gain experience with the equipment.

Welding Techniques

Welding equipment is in operating and apparently producing satisfactory closures.

Hydrostatic Cladding

Current thinking is that a metallurgical bond will not be required. The procedure that is planned consists of applying hydrostatic pressure at about 400°C to make the aluminum can conform to the surface of the uranium which has been grooved in various configurations.

Thermal Cycling

Work is proceeding on the basis that thermal cycling is a good substitute for irradiation tests. Equipment was in operation for thermal cycling fuel elements with steel cores -- principally to test out functioning of the equipment.

Inspection for Fuel Element Quality

The Israeli have developed a method for X-raying the slug in a narrow beam. They are also working on a method for detecting leaks by pressurizing can slugs in helium and looking for helium leaks with a mass spectrograph. The mass spectrograph is on hand but so far has not beem made to operate satisfactorily.

Attachment 4(2)

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VISIT TO SWIMMING POOL REACTOR AT NAHAL SOREK

The swimming pool type reactor constructed by AMF is in limited operation with a restriction to five megawatt hours per week. The restriction was imposed because certain parts of the containment system were incomplete. This work has now been completed; permission to operate continuously at a power of 5 megawatts is expected soon.

Apparently little difficulty was experienced with installation and start-up of the reactor. Dr. Pelah stated that everything seemed to work pretty much as AMF had predicted.

Presently the only facility which is actively used for research and training is one "rabbit" (a facility for rapid insertion and removal of samples during reactor operation). Work with this facility includes activation of ore samples and analysis for uranium content by delayed neutron measurement. Five more such installations are planned and should be in operation within the next six months.

There are six beam facilities which are planned to be used for the following experimental projects:

1. Neutron defraction

2. Crystal monochrometer

3. Inelastic scattering

4. Study of neutron-gamma reactions by use of a facility specifically designed to provide high intensity

5. Study of various nuclear reactions at very low temperatures -- initially liquid nitrogen and perhaps eventually liquid hydrogen

6. Mass spectrograph supplied by ions produced as fission products near the reactor

Current plans for use of the thermal column are for performing exponential experiments for light water and natural uranium in various configurations attempting to see if a reproduction factor above unity can be obtained. It is recognized by the staff that even success in this experiment would be of little practical significance but it is considered valuable training experience. The reactor operating staff now consists of five reactor operators but eventually will include nine reactor operators plus a staff in mechanical engineering, physics, and nuclear chemistry. The research

Attachment 5(1)

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projects using the reactor will be done in collaboration with other research establishments in Israel such as Technion University, Weizmann Institute, and Hebrew University. Initially, at least, the cost of operation of the reactor will be supported entirely by the Government. Eventually it is expected that a hot laboratory will be built near the reactor but the timing for such construction is very indefinite.

Attachment 5(2)