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NOTES ON A STUDY TOUR OF THE UNITED STATES OF AMERICA

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INTRODUCTION

This report outlines the results of a four months' overseas study tour to the United States of America, which was authorized by the Commonwealth Government as part of a programme of training Bureau of Mineral Resources officers in techniques of oil exploration.

The main purpose of the tour was to receive geological training in exploration techniques of several oil Companies; the techniques included the acquisition, presentation and interpretation of geological data, and its integration with geophysical data. Because about three months were spent in one area -- the 'Permian Basin' of south-eastern New Mexico and west Texas -- the basic training was concentrated mainly on reef complexes and associated sediments. The remainder of the tour was spent in brief visits to several establishments where research on carbonate rocks is carried out, and the results applied directly to oil exploration.

A summary of my itinerary was as follows :

June 28, 1962, Departed Canberra for San Francisco.
July 1 - August 25,1962, with the Standard of Texas Company, at Roswell, New Mexico.

August 25 - September 12, 1962, about one week at each of Austin, Houston and Dallas (Texas) and Bartlesville (Oklahoma).

September 12- October 29, 1962, with Phillips Petroleum Co. at Midland, Texas.

October, 30, 1962 Departed San Francisco for Canberra.

I wish to acknowledge the extreme kindness and willing assistance of my several American hosts, who went to considerable trouble to ensure that I received the maximum benefit from my tour. My personal letters of thanks have been sent to organisations and individuals who assisted at many stages of the tour; in particular, major assistance was received from the following:

The Standard of Texas Company, at Roswell, New Mexico.

The Bureau of Economic Geology, at Austin, Texas.

Dr. N.J. McMillan, of Tennessee Overseas Co.Houston.

Dr. Duncan A. McNaughton, of Dallas, Texas.

Phillips Petroleum Co., at Bartlesville, Oklahoma and at Midland, Texas.

Mr. D.M. Johnstone,(of WAPET) at Roswell, New Mexico, and at Houston, Texas.

Numerous other organisations and individuals issued invitations to interesting projects, but most of these had to be declined because of other engagements.

The details of the towr are discussed, in chronological order, in following sections of this report.

ROSWELL, NEW MEXICO

From July 1st, 1962 to August 18th, 1962, was spent in the Exploration office of the Standard of Texas Company at Roswell in south-eastern New Mexico. Standard of Texas is a wholly-owned subsidiary of the California Oil Company and is an integrated company, i.e., it explores for, produces, transports, refines and markets oil and gas. The Roswell office of Standard of Texas has the status of a District Office within the Amarillo (Texas) Division. The Company's headquarters are at Houston, Texas, and those of the parent company are located in San Francisco, California.

The Roswell District Office controls the Company's exploration activities in the whole of the State of New Mexico. At the time of my visit the staff consisted of nine geologists, one landman, one scout, two typists, two draftsmen, one tracer and one office boy/printing machine operator. A considerable number of itinerant specialists from CalResearch, California, give lectures at all Standard of Texas offices; in addition, the Roswell office utilises the services of a stratigrapher from the Midland (Texas) Division office, and of geophysicsts and a photo interpretation specialist from the Houston headquarters.

The Standard of Texas Company holds its annual budget session in late August, when funds are allotted for projects to be carried out in the following twelve months. During my visit, the Roswell staff was extremely busy in preparing projects for consideration at the Budget session; a few Company wells were in progress in the north-western part of the State, and one geologist was engaged in field work there, but the remainder of the staff were engaged in office work of one kind or another. This work invariably involved the use of various types of logs run in the wells, and the sample logs of those wells. Although facilities were available, and samples were usually available, it was unusual to see a geologist examining samples from wells on which he was working.

My time at Roswell was spent almost entirely in office work, but two one-day field excursions were undertaken, and I attended one of the weekly Scout Check meetings at Hobbs, New Mexico. Lectures by visitors from CalResearch, Houston and Midland were attended whenever the topics were not on the Company's secret list.

After reading the more reliable published works on Permian stratigraphy and reef complexes of what is locally called 'the Permian Basin', I began the preparation of cross-sections and structure contour maps, using information from various types of logs run in the wells, the sample logs and actual samples, where necessary. The first project was from shallow oil producers in the Vacuum Field, located in Lea County, New Mexico and on the Central Basin Platform, between the Delaware and Midland Basins.

Production from the Vacuum Field comes from fractured dolomite of the Permian Guadalupe Series; the Field is 7 miles long and 5 miles wide and contains 220 producing wells sited on a pattern of 40-acre spacing. Allowable production for these wells was 30 barrels per day, at this time, but the Well Record Cards showed that many of them had had an initial potential of about this figure, and often only after extensive acid fracturing. The structure in the Permian sediments here was a broad anticline with dips of less than one degree -- therefore a small error in interpretating formation tops from the logs meant a reversal of the true structure.

Upon completion of work in the Vacuum Field I did much the same work in older Permian rocks of the Leonard Series, but this differed in that the producing horizon was the Abo Reef. At this stage, I logged one well completely and looked at samples of the reef from several wells. The next stage of work involved tackling some stratigraphical and structural problems; these were mainly in Devonian or older sediments and the problem usually involved the determination of either a fault or an unconformity.

Members of the Roswell Geological Society invited me to accompany them on two road-logging trips which were undertaken to prepare for a field excursion of the Society later in the year.

The first trip was made through the back-reef facies of the Permian Reef Complex, exposed in Dark Canyon and at Sitting Bull Falls. Excellent examples of the rapid lateral passage of dolomite into 'red beds' were noted. On the second trip, the party climbed into the head of McKittrick Canyon, and descended 1400 feet into it. Here the contact between the Goat Seep Reef and the Queens Formation (dolomite of the back-reef facies) was clearly visible, and dolomite of the Seven Rivers and Yates Formations overlie the Goat Seep Reef. Towards the mouth of the canyon the Capitan Reef overlies the Goat Seep Reef.

I accompanied the Standard of Texas Scout to a weekly meeting of the New Mexico Scouts' Association, held at Hobbs in south-eastern New Mexico. In addition to normal scouting duties, this association arranges the sale of samples from wells, to any interested Company. Individual Scouts bring the samples to Hobbs, where the Association employs a full-time staff of three people to make cuts of the samples and to distribute them on request. The Companies are charged 7 cents for each 10-foot sample, or 5 cents if they provide their own sample bags. Profits go to the Scouts' Association, which has become quite rich from the venture.

Since the formation of a commercial Scouting Service in 1961, attendance at the New Mexico Scouts' Association meetings has dwindled from about 35 to about 15. On August 15th, 1962, 13 Scouts attended the meeting; one of these came from the U.S.G.S., and one from the New Mexico Oil Conservation Commission. Details of 140 wells were read in 180 minutes.

Whilst in Hobbs I spent about two hours in the office of the New Mexico Oil Conservation Commission. This office, which is staffed by a small number of engineers and geologists, is responsible for policing the Conservation laws in south-eastern New Mexico. In addition it has the unenviable task of endeavouring to standardise stratigraphy from the reports submitted by Companies, many of whom use

differing nomenclature. Another function of the Hobbs office is the computation of reserves in various oil pools, using the data on Well Record cards. The history of each well in the area is filed in the office. A small but important function of this office is the control of wells drilled through the potash deposits in the Carlsbad district of New Mexico; mine owners have the right to refuse to allow the drilling of oil wells on their leases, due to the risk of solution of the deposits and collapse of the mines. Strict engineering control is enforced on any wells which are allowed on the leases.

The most interesting lecture I heard was delivered by an officer of CalResearch, on the subject of chromatography of oils. Crude oil is analysed in a chromatograph, where it begins to disintegrate at temperatures of about 450 degrees Centigrade. The results of the analysis are plotted automatically on a graph; the peaks represent propane, butane etc. and the lows represent the numerous isopolymers. At CalResearch the analysis extends to $C_{14}H_{30}$, which is considerably further than the limit reached by other operators; at the high end of the scale, differences in constituents of the crude are difficult to distinguish but CalResearch claims that it can be done. Before doing an analysis it is important to know the method of sampling the crude, the mode of transport, type of packing, and in the case of a new well, all available information from the drill stem test. All of these factors could affect the interpretation of results, e.g., the aromatic end of the scale is much affected by water content in the crude.

The results of the analysis are plotted, using a 'paraffinicity index' as the yardstick, and comparisons made with results from other crudes. The basic assumption made is that two different oils cannot form in the same source. Using the results obtained in the chromatograph it is possible to predict that crudes are from the same or different reservoirs, or that reservoirs are joined. Claims that a well is a dual or triple producer can be simple verified by this method.

One practical example which was illustrated was the case where oil had been produced from fractures in several wells, drilled in different formations. An analysis by chromatograph showed that the crudes in each had the same composition, and it was concluded that the fractures cut obliquely across the strata. In another case illustrated, two oils of slightly different composition had been obtained from the same well. The results, when plotted, indicated that a slight amount of oil was entering the well from another untapped, and un-noticed, reservoir.

The depth of burial of the reservoir has no apparent significance on the results when the depths are only slightly different, but a difference of say from 2000 to 10,000 feet, could seriously affect the results obtained from the chromatograph. CalResearch has found that in tests of crudes from off-shore areas of the Gulf Coast, all aromatic hydrocarbons disappear at a depth of 10,500 feet.

The time taken to analyse one sample in the chromatograph is about 2 hours, but the process, once begun, is automatic and requires only occasional supervision to see that the recording instruments are functioning on scale. The cost per sample is 30 dollars.

An item of interest gleaned from a News Bulletin issued by CalResearch in July, 1962, stated that, after extensive trials, the organisation had not then decided which method of presentation of data on punch cards to adopt. The KWIC (key word in context) system was generally favoured. In a trial of this method, information was extracted from a batch of 1700 well record cards, in a time of 6 minutes and at a cost of 6 dollars.

AUSTIN, TEXAS

The period from August 18th to August 25th, 1962, was spent at the Bureau of Economic Geology at Austin, Texas. This organisation is a semi-State, semi-University of Texas one, and consists of the Director, Dr. Peter T. Flawn, and a staff of 11 geologists, 4 draftsmen, a Librarian and typistes. The Bureau of Economic Geology conducts considerable amounts of research in carbonate petrology, provides ex officio lecturers to the University of Texas, examines candidates for higher degrees in geology, does a considerable amount of field mapping and acts also along the lines of a Bureau of Mineral Resources Resident Office, e.g., it has one geologist whose function is to deal with members of the public who bring specimens for identification or seek information on geological subjects.

At the time of my visit, several staff members including Dr. Robert L. Folk, were absent on vacation. Dr. Virgil E. Barnes, who had intended to be my guide for some days, was ill; despite these difficulties the Director of the Bureau went to considerable trouble to extend all the facilities of his depleted office. A car and driver were put at my disposal for one day, and arrangements were made for me on another occasion, to accompany two staff members who were examining the field work of a candidate for the degree of Ph.D.

After reading some essential parts of Dr. Virgil. E. Barnes' "Ellenburger Volume" (a University of Texas publication whose Introduction contains an excellent description of field methods) I obtained a field excursion Guide Book, also written by Dr. Virgil. E. Barnes, and set off to follow some of the trips described. A measured section of the Ellenburger Formation was examined in the vicinity of Marble Falls, Texas, and good exposures of bioherms in this formation were also examined in the same locality. The overlying Cretaceous limestone was examined and a brief visit was paid to a granite quarry at Marble Falls. This quarry produces granite which has been used as facing stone in many large buildings throughout the United States; the stone was formerly quarried by blasting, but eventually the continual blasting operations caused an internal stress in the granite, and blocks began to fail after erection. At present the blocks are sawn from the quarry face, by means of an intricate system of wire saws, before being sawn to size in a normal rock saw.

On a second field excursion, I accompanied Drs. Rodda and Fisher during an examination of the field work of a Ph.D. candidate who had mapped some of the Cretaceous formations in the Austin area; his work was done under a grant awarded by the Shell Company. In brief, he was mapping reefs in Cretaceous formations, and had produced very detailed maps: in one instance he referred to 'a calcarenite bank with a very steep slope'; this slope gave a difference of elevation of 40 feet in a distance of two miles.

At Austin, I visited the Dept of Geology at the University of Texas, where Dr. Charles Bell gave interesting information on the Cambrian System of the United States, and where I was shown the computer system. This is so arranged that other Texas universities, and State colleges, can feed information to the machine by teletype and receive results by the same means.

Visits were paid also to the Bureau's sample storage sheds and laboratory of invertebrate palaeontology, both located in the suburb of Balcones.

HOUSTON, TEXAS

The period August 25th to September 1st, 1962 was spent in Houston, Texas, and environs. In Houston, some time was spent in the offices of Tennessee Oil and Gas Company, where Dr. N.J. McMillan, formerly on the staff of the Geological Branch of the Bureau of Mineral Resources, works in a special 'brains trust' section which deals with structural and stratigraphical problems, and with problems of carbonate rocks and sandstones. This section tackles problems which arise in any area of the Company's operations within the United States.

The remainder of the time in Houston was spent in the offices of Tennessee Overseas Company. This Company had just closed its operations in Venezuela and a member of the staff from that area had been transferred to Houston to begin compiling all available information on the geology of Australia; the Company was then seriously considering oil search operations in this continent. Several discussions were held with the Chief Geologist, Dr. Harrington, and his staff geologist engaged in the Australian compilation. Although I had the impression that these people were interested in specific parts of Australia, they were careful not to reveal them. The bulk of their questions concerned the Great Artesian and Otway Basins.

From Houston, a trip was made to Freeport, on the Gulf of Mexico, to inspect a salt-water conversion plant operating there. This plant is one of five conversion plants planned and built by the United States Government; each plant operates on a different method, and each will operate for about three years. At the end of that period, the results will be analysed and the best method selected for large-scale conversion of salt water to fresh. As well as the actual processes under trial at present, the composition of material used is also under trial, e.g., at Freeport, the vertical distillation cylinders are made from different metals. (See Appendix 1).

The United States Government, through its Chamber of Commerce, is endeavouring to encourage its citizens to take an interest in the salt water conversion plants, and visitors are welcome.

The Freeport plant, owned by the United States Government but operated by a firm of Denver engineers, began operations in June, 1961. Some damage was caused by hurricane 'Carla', when the office building and control room were flooded to a depth of six feet. The conversion process in this plant is 'long-tube vertical distillation'; there are 12 tubes.

Sea water is pumped from a flume leading to Dow's Chemical Plant'A', which is adjacent to the Freeport conversion plant. Energy, in the form of steam, is also supplied by the Dow plant. 1,000000 gallons of fresh water are produced per day; half of this is sold to the city of Freeport, at 20 cents per 1000 gallons; the other half is sold to Dow Chemical Plant'A'. Cost of production of fresh water ranges from 1.25 to 1.40 dollars per thousand gallons.

One striking feature of the Freeport plant is that it is very compact; the whole plant, including office block, could be placed on about 40 perches of land. At present a staff of 12 is required to run the plant, but the same staff could operate a plant with a capacity four times as great.

Details of the demonstration plants either operating or scheduled for construction in the United States are :

AREA	LOCATION	PROCESS	CAPACITY
Gulf Coast	Freeport Texas	Long-tube vertical multiple-effect distillation.	1,000,000 gallons per day.
West Coast	San Diego, California	Multistage flash distillation.	1,000,000 gallons per day.
Northern Great Plains	Webster, South Dakota.	Electrodialysis (membrane process)	250,000 gallons per day.
Arid Areas of the Southwest	Roswell, New Mexico	Forced-circulation vapor-compression.	1,000,000 gallons per day.
East Coast	Wrightsville Beach, North Carolina.	Freezing	250,000 gallons per day

DALLAS, TEXAS

The period from September 1st to September 6th, 1962, was spent in Dallas, Texas.

In Dallas I was indebted to Dr. Duncan McNaughton for arranging some projects which he, knowing the general background of Brueau geologists, thought I ought to undertake. I went to the Huckaba-Morgan Company, a firm of consulting reservoir engineers who have a sound local reputation and who have proved their ability by finding extensions of known pools by spare-time study of records of reservoir pressures.

The principals of this firm explained reservoir engineering, and illustrated their explanations with many practical examples, particularly with references to the calculation of the optimum time to begin water flooding in fields of declining pressures. The possible reasons for anomalous pressure behaviour were also explained.

The Huckaga-Morgan Company was one of many small companies of consultants with offices in the Republic National Bank Building in Dallas. Dr. McNaughton explained that such companies get a lot of work from banks, who carefully scrutinise the propositions advanced by numerous individuals who try to borrow money for drilling wells. The role of banks in the petroleum industry had been noticed in Roswell, and was very apparent later at Midland, Texas.

At Dallas I inspected an overhead projector of the Tecnifax Company, which is one of the larger companies supplying visual-aid equipment. One of the advantages of this particular equipment was that the machine acts as a polarising microscope, and the insertion of a strip of cellophane will blank out some features of a slide, allowing the viewer to concentrate on the particular features which are to be stressed. Dr. McNaughton demonstrated slides he had prepared of the Amadeus Basin. The equipment is relatively inexpensive, but would require a full-time draftsman or artist to prepare the slides.

BARTLESVILLE, OKLAHOMA

From September 6th until October 29th the Phillips Petroleum Co. gave training in various aspects of petroleum geology. The period September 6th to September 12th was spent at the Company's headquarters at Bartlesville, Oklahoma. The company has about 5000 employees at Bartlesville, whose total population is about 21,000.

After a brief period in the Exploration Department (International), I spent three days with the Special Projects Group of the Land and Geological Department of Phillips Petroleum Company. The Special Projects Group consisted of a small number of geologists and engineers, whose function was research with a view to locating new drilling targets. The geologists all specialised in carbonate rocks.

The Special Projects Group followed generally R.L. Folk's classification of carbonate rocks, and were engaged mainly in searching for reefs, by reconstructing the environment of deposition, after examining all available samples from wells in the area of interest. Considerable stress was placed on the occurrence of green, blue-green and red algae.

The Group had a complete set of thin sections and acetate peels of the various types of algae, and of the more important carbonate types in Folk's classification. After I had studied these slides and peels, their practical application was demonstrated by reference to the Group's recently-completed project. In brief, the result of this was the discovery of a deep but untested reef in Cretaceous carbonate rocks.

Whilst with the Special Projects Group, I also examined micro-slides of sandstones which had been injected with coloured plastic, which showed the porosity of the sediments.

MIDLAND, TEXAS

I spent the period from September 12th to October 29th, 1962, at the Division Office of Phillips Petroleum Company at Midland, Texas. This period was probably the most useful of my tour: by this time I had a reasonably good grip on stratigraphy of the Permian and older rocks of West Texas and south-eastern New Mexico, and in a Division office, with its several departments, various types of different information can be acquired in the one building.

Phillips Petroleum Company has a training programme for recruits; the period of training is approximately 12 months and consists of :

(a) about 6 weeks with the Company's photo-interpretation experts at Denver, Colorado; part of this time is spent in field work, usually in the Denver area.

(b) about 6 weeks with a seismic crew, in any available area.

(c) 17 weeks in the Division office at Midland, Texas.

(d) about 6 months in the Company's headquarters at Bartlesville, Oklahoma.

If the trainee has made satisfactory progress in all phases of the programme, he is then posted to one of the Company's offices. The programme is fairly demanding; in addition to his day-time activities, the trainee gets a considerable abount of 'homework' and is required also to complete numerous questionnaires contained in the Company's Training Manual of several hundred pages.

At Midland I followed the Company's training course, and completed some work in each section of it. A few brief inspections were made of commercial organisations which provide various kinds of service to the petroleum industry, but the time spent with Phillips Petroleum Company was divided roughly as follows :

(a) 8 days were spent in logging samples from old wells. The samples were all from wells which had penetrated Permian reefs. My tutor here was Mr. Addison Young, who has spent about thirty years in the Permian Basin area of West Texas. Samples were examined for fluorescence and porosity as well as lithology.

(b) 8 days were spent with the Development Section. This involved alternate days of travelling (about 500 miles per day) to wells in progress, and logging the samples in the Company's core and cuttings laboratory. Normally, seven wells were watched in this manner; one was in West Texas and the remainder in south-eastern New Mexico. Whenever a drill-stem test was scheduled on any rig within reasonable distance of Midland, I went to observe it. Four such tests were attended; the packers failed in three and the fourth recovered only salt water.

During my trips around the wells I had a close look at the mud-logging units operated by various service companies such as Baroid, Core Lab, Hammit-Mangum and Cook Testers. All of these units were self-contained in caravans; some were more elaborate than others, and the Hammit-Mangum caravan was designed to permit the collection of samples in a sink inside, instead of from the drill itself. All of the operators charged about 140 dollars per day for these services. The normal staff consisted of two men to each unit.

(c) One day was spent in studying maps of various oil pools. In this particular study one geologist was looking at oil pools in shallow structures, then transferring his study to the records of deeper wells in the same area, on the basis that shallow structures often reflect deeper ones. The same geologist also demonstrated the method of financial analysis used before seeking permission to drill a well.

(d) Six days were spent in the Exploration Section preparing structure contour maps of deep horizons in Devonian and Ordovician sediments. In each case, shallow structures were known, and the object of preparing the map was to ascertain if these structures were reflected in older sediments. Some of the examples attempted involved the solution of a common problem of fault versus unconformity.

(e) One day was spent in the study of lithofacies maps of Ordovician, Siluro-Devonian and of each unit in the Permian sequence of the area. These maps had been prepared by three stratigraphers, who had been working for several months on the project. One of these geologists had worked for 10 years in the Insoluble Residues Laboratory (a commercial service in Midland) and he described briefly the methods used. An elaborate log can be produced from inspection of the insoluble residues of well cuttings, but a lot of practice with material from one area seems necessary before stratigraphic units can be properly recognised. Most oil companies in Midland regarded insoluble residues as useful stratigraphic tools.

(f) Two and a half days were spent in interpreting logs of wells which had penetrated Permian reefs, then making a cross-section of the reef, an ispoach map of the reef, and a structure contour map of the top of the reef.

(g) Two and a half days were spent in a field trip to the Guadalupe Mountains. I joined a party of eight Phillips' geologists on a tour of the reef, fore-reef and basin sediments of the Captain Reef and the Delaware Basin. One of those present was Dr. W. Cronable, of the Special Projects Group at the Company's Bartlesville headquarters who had previously demonstrated microslides to me, and who

had joined the present excursion to collect more material for study.

Accompanied by a guide provided by the United States National Parks Service (his function was to prevent the removal of samples) the party climbed the fore-reef side to the base of the Capitan Reef, at the eastern end of McKittrick Canyon. Dr. Cronable pointed out occurrences of red algae, which are common in reef and fore-reef, and sampled them. From McKittrick Canyon the party drove south to El Capitan and Guadalupe Peak, inspecting numerous excellent exposures of the dark-toned basin sediments.

Other exposures of the Capitan Reef were inspected in Dark Canyon; here the reef is low and it is difficult to delineate unless light conditions are right to show masses of fossils bonded by blue-green algae.

(h) In my spare time I made a set of subsurface contour maps; this was the normal procedure in the training programme, designed to improve efficiency in contouring.

Whilst in Midland, I paid brief visits to the Palaeontological Laboratory and to the Permian Basin Sample Laboratory, attended three lectures sponsored by the West Texas Geological Society, and one lecture, coupled with a practical demonstration, on IBM computers. I paid a visit to the office of the Texas Railroad Commission, in search of copies of the State's oil and gas conservation laws. However the only literature available is retained in eight volumes in the Commission's offices.

The Palaeontological Laboratory is a commercial venture operated by Messrs. R.V. Hollingsworth and Harold L. Williams. It uses fusulinids for correlation purposes and has a reference library of about 10,000 slides. Cuttings from wells are examined and the stratigraphic results distributed twice monthly to subscribers. Most of the major companies subscribe to the service, and some request special information from time to time.

The Permian Basin Sample Laboratory is another commercial service. The Laboratory employs a staff of 6 geologists, who log the samples of every drilled in the Permian Basin and sell the logs to subscribers. The logs are of about the same standard as those produced by the companies themselves, but the Laboratory was considering an improved version modelled on the Amstrat system. When a well is logged, the samples are forwarded from the sample laboratory to a central Sample Library in Midland.

The West Texas Geological Society has about 1000 financial members, of whom 600 reside in Midland. The Society holds regular luncheon meetings, and occasional evening ones. The sale of maps and Guide Books has made the Society very profitable.

A practical demonstration of an IBM 1620 computer, with a Calcomp slave (output) unit, was preceded by a lecture on the uses of the machine in the geological and geophysical fields. The IBM 1620 is a 20,000-digit computer which uses punch cards. The machine double-scans 250 punch cards per minute in the input section, stores the relevant information in its memory section, and produces the result in the slave unit.

The IBM 1620 performs tasks so rapidly that it is difficult for the operators to hire it sufficiently to pay for the machine. The input and memory sections are hired together for 2200 dollars per month; (no operators supplied); the hire of the Calcomp slave unit costs 2000 dollars per month.

The most impressive demonstration was the drawing of a structure contour map from depths of formation tops extracted from punch cards in the input section. The stylus of the slave unit can move only in straight lines, therefore a rather angular set of contours is produced. In the example shown, the structure, which included a fault, was readily discernible and agreed substantially with that drawn manually by a geologist who had had 15 years' experience. The advantage of the mechanical method is that it produces the true result whereas the human method invariably produces the most favourable of several alternatives.

APPENDIX 1

Details of Freeport Demonstration Plant for Saline Water Conversion.

The following details are taken from the 1961 Saline Water Conversion Report, issued by the Office of Saline Water, United States Department of the Interior.

Architect-Engineer	W.L. Badger Associates Ann Arbor, Mich.
Construction contractor	Chicago Bridge and Iron Company, Chicago, Ill.
Capacity of the plant Salinity of the untreated water	1,000,000 gallons per day 35,000 dissolved parts of salt per million parts of water (ppm).
Maximum salinity of the product water	50 ppm total dissolved solids.
Salinity of plant effluent	4.0 times the salinity of sea water or approximately 140,000 ppm.
Ratio-- pounds of product water per pounds of steam.	9.5 lb.
Initial plant cost	$ 1,255,712.
Ground breaking	August 30, 1960.
Construction completion date	April 7, 1961.
Completion of testing	June 6, 1961
Heat transfer coefficients	350-750 BTU/hr-ft -- F.
Operating temperature range	250 F for the first effect ranging down to 120 F in the 12th effect.
Maximum operating temperature	300 F.
Management and operating contractor.	Stearns-Roger Manufacturing Company, Denver, Colo.
Authorized operating period	September 2, 1965.
Corrosion testing	Tubes in effects 1, 5, 6, 8 and 11 are carbon steel. Tubes in effects 3, 7, 10 and 12 are aluminium brass. Tubes in effects 2 and 9 are admiralty metal, and the tubes in the 4th effect are copper-nickel 9 - 10.

APPENDIX 2

Literature acquired in the United States, and lodged in the Library of the Geological Branch.

Author	Title
ADAMS, JOHN EMERY, 1929	Triassic of West Texas
ADAMS, JOHN EMERY, 1930	Origin of oil and its reservoir in Yates Pool, Pecos County, Texas.
ADAMS, JOHN EMERY, 1932	Anhydrite and associated inclusions in the Permian Limestone of West Texas.
ADAMS, JOHN EMERY, 1933	Island in Permian Sea.
ADAMS, JOHN EMERY, 1934	Origin, migration, and accumulation of petroleum in limestone reservoirs in the western United States and Canada.
ADAMS, JCHN EMERY, 1935	Upper Permian stratigraphy of West Texas Permian Basin.
ADAMS, JOHN EMERY, 1936	Oil pool of open reservoir type.
ADAMS, JOHN EMERY, 1940	Stratigraphy, eastern Midland Basin, Texas.
ADAMS, JOHN EMERY, 1940	Structural development, Yates area, Texas.
ADAMS, JOHN EMERY, 1944	Upper Permian Ochoa Series of Delaware Basin, West Texas and Southeastern New Mexico.
ADAMS, JOHN EMERY, and FRENZEL, HUGH N., 1950	Capitan Barrier Reef, Texas and New Mexico.
ADAMS, JOHN EMERY, et.al.1951	Starved Pennsylvanian Midland Basin.
ADAMS, JOHN EMERY, 1953	Non-reef limestone reservoirs.
ADAMS, JOHN EMERY, 1954	Scientific Side of petroleum geology.
ADAMS, JOHN EMERY, 1960 and RHODES, MARY LOUISE	Dolomitization by seepage refluxion.
ADAMS, JOHN EMERY, 1962	Foreland Pennsylvanian rocks of Texas and eastern New Mexico.
ADAMS, JOHN EMERY,	Late Palaeozoic reef sequences in West Texas.
A.A.P.G. SUBCOMMITTEE ON THE PERMIAN, 1940	Classification of Permian Rocks.

Note: All of the works listed above are in the form of reprints and comprise a full set of the publication of John Emery Adams, of the Standard of Texas Co. They were present by Mr. Adams.

BARNES, VIRGIL, E., 1958 — Field Excursion, Eastern Llano Region. (Guide Book Number 1, Bureau of Economic Geology).

CLOUD, PRESTON E.,Jr. and BARNES, VIRGIL, E.,1946 - The Ellenburger Group of Central Texas.

HUCKABA, WILLIAM, A., and MEYER, WILLIS G., 1958 - Common fallacies in oil and gas reserve estimates.

MORGAN, NEIL R., 1959 — Criteria for determining type of drive in oil and gas reservoirs.

MEYER, WILLIS, G., 1958 — Use of oil and gas property appraisal reports.

IBM — IBM 1620 Programs for Petroleum Exploration.

IBM — IBM 1620 Programs for Petroleum Engineering.

NEW MEXICO OIL CONSERVATION COMMISSION 1961 - RULES AND REGULATIONS.

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The following maps have been filed in the Drawing Office of the Geological Branch:

Geologic Highway Map of New Mexico (in colour)

Permian Basin Wildcat Map. (black and white)
