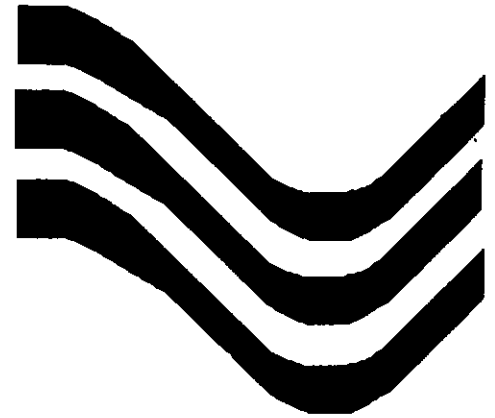


TUFFP

Newsletter



A Semiannual Publication of the Tulsa University Fluid Flow Projects

August 1987

Volume 1, Number 2

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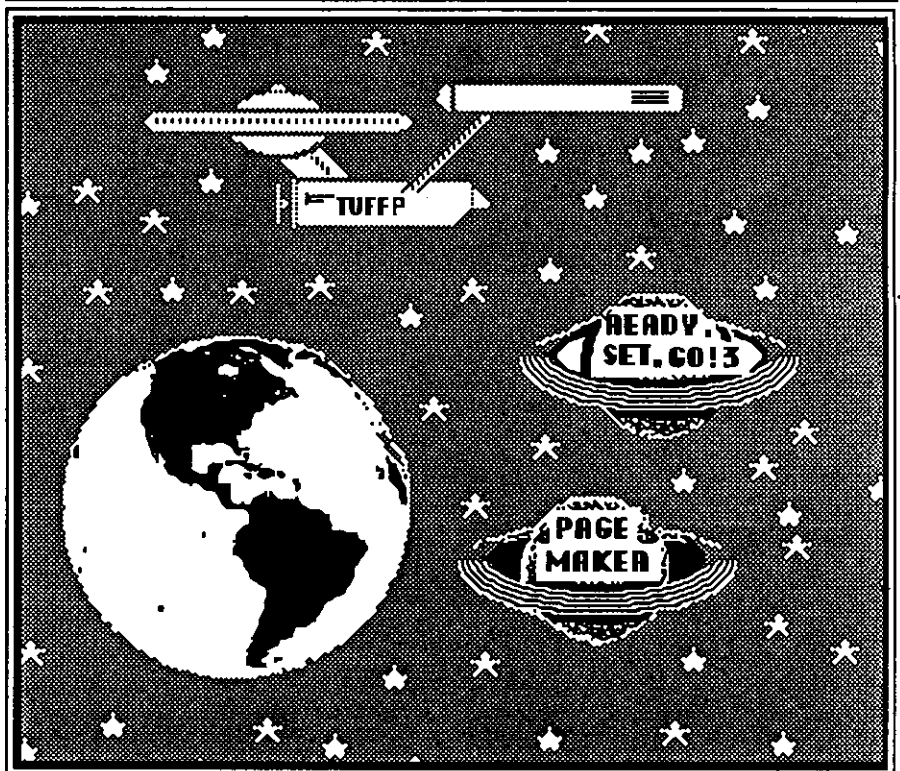
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TUFFP Talk



TUFFP BLASTS OFF INTO THE WORLD OF DESKTOP PUBLISHING

TUFFP entered the world of desktop publishing this summer with the purchase of *Ready, Set, Go! 3* (RSG/3) and *Pagemaker*. This TUFFP Quarterly Newsletter is a product of RSG/3. Its vast improvement upon those newsletters released in the past can be clearly seen.

RSG/3 allows graphics,

various column layout schemes, multiple fonts and font sizes, and text imported from already existing text files such as MacWrite or Microsoft Word. Actual photographs taken by a Video Tape Camera can also be used.

(Continued on page 2)

(Desktop Publishing- Cont. from page 1)

In the past, a simple word processor was used to produce the newsletter. Its capabilities did not extend to the implementation of graphics and its layout capabilities were extremely limited. However, *RSG/3* has added a professional touch to the semiannual newsletter and has improved readability and appearance.

Pagemaker was used in a software review which was recently submitted for publication in *SPE MICROCOMP NEWS*. It also clearly illustrates the advantages and capabilities that desktop publishing packages extend to documents normally utilizing word processing software. It is hopeful that publications such as this newsletter will show SPE the vast improvements that desktop publishing software could offer to the drabness and outdated, non-laser appearance of their microcomputer publication.

TUFFP Represented at BHRA Conference

Dr. Brill and Dr. Shoham represented TUFFP at the BHRA 3rd International Conference on Multiphase Flow in The Hague this May. A technical paper detailing a model for the developing slug growth observed at Prudhoe Bay was presented by Stuart Scott. Unlike many other conferences, the entire program was devoted to multiphase flow, with particular emphasis on the petroleum industry. The conference had an excellent program and was well attended by multiphase flow researchers from around the world.

Stuart Scott to Join In September



At the end of this summer, Stuart Scott will be joining the Production Simulation Section of Phillips Petroleum Company, Bartlesville, Oklahoma. He has served as the Shell Doctoral Fellow, TUFFP Research Assistant, and System Manager of TUFFP Computing Facilities for the past four years. He will continue working with us on the completion of several papers during the next academic year.

Purchase of Mac II Considered

This spring, *Apple Computer* announced their newest and most powerful personal computer, the Macintosh II. It features the very fast Motorola 68020 microprocessor chip which is also used by Sun and Apollo workstations. The Macintosh II has color graphics and can simultaneously display two complete 8" by 11" size pages on the screen. Unlike the Macintosh Plus, the Macintosh II has six expansion slots for data acquisition boards, etc. The Macintosh Plus has become the most frequently used computer at TUFFP, with people waiting in line to use it. Purchase of a Macintosh II would help alleviate this problem and will be considered in 1988.

Taitel to Teach Multiphase Modeling Class at TU

Dr. Y. Taitel will spend the Fall 1987 semester as a visiting Distinguished Professor of Petroleum Engineering at The University of Tulsa. During this time he will teach a graduate course on mathematical modeling of two-phase flow phenomena. The class will be taught 1:30 - 4:30 p.m. on Thursdays, September 3- December 10. TUFFP representatives should consider attending if located in the Tulsa area. Dr. Taitel will also supervise the experimental project on severe slug flow for TUFFP.

TUFFP Basketball Team Destroys the TU C.S. Department 50-34

TUFFP employees faced off against the Computer Science Department Professors in a friendly pick-up basketball game on July 10. Representing the Fluid Flow Projects were Stuart Scott, "Jupe" Arirachakaran, Josh Tungsubutra, Arthur Corcoran, Lorri Jefferson, and Florence Kung. Josh Tungsubutra was leading scorer for TUFFP with 24 points.

First half play proved to be a close match, both teams battling neck and neck for the lead. However, endurance, youth and speed won out over the wisdom and experience of the professors. When the final buzzer rang 40 minutes later, TUFFP had won the game 50-34.

Short Courses Lose Money

The TUFFP short course, *Two Phase Flow in Pipes*, held in Tulsa May 4-8 lost \$3,730. Of the 26 participants in the course, 14 received free registration since they represented a TUFFP member company.

Registrations at the London short course May 26-29 were less than anticipated. There was a total of 11 registrations, 8 of which were from TUFFP or BHRA member companies. This course lost \$9,701.

The combined 1987 short course losses were equivalent to the income from one member company. Future short courses in London will probably be scheduled every other year to coincide with the BHRA International Conferences on Multiphase Flow.

Amoco Thermal Project Delayed

Discussions with companies interested in the contract research project titled *Thermal Fluid Properties and Heat Transfer Coefficients for*

Drilling and Well Completion Fluids in Tubes and Annuli have been terminated. Although all companies were extremely interested in the project, funding required to conduct the project could not be obtained. In addition, Amoco decided not to make their circulating wellbore temperature simulation model available to participants.

Several New Members Possible

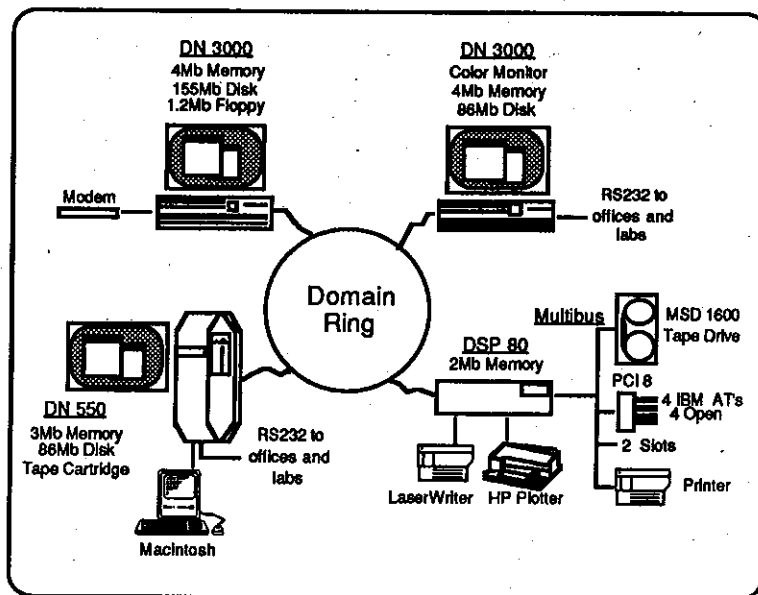
Discussions are underway with Exxon Production Research Co., AGIP, China National Offshore Oil Company, and Scientific Software-Intercomp to join TUFFP in 1987 or 1988.

We have not received notification of intent from any existing TUFFP members to terminate their membership for 1988. We consider this a positive sign and an indication that perhaps the Petroleum Industry worldwide is beginning to recover. An increase in members for 1988 would permit us to accelerate existing projects and also initiate new projects suggested by members.

TUFFP Upgrades Apollo Workstation Network

The Tulsa University Fluid Flow Projects has recently purchased a new Apollo DN3000 workstation. The computer features a color monitor, 86 megabyte hard disk, and 4 megabytes of main memory. A Courier 9600 baud modem has been added to the Apollo computer network. This new purchase brings the number of workstations to four at TUFFP.

Two additional Apollo workstations are maintained by the Petroleum Engineering Department on the Tulsa University main campus. Recent donations of equipment by Amoco Production Research Co. have also led to the adoption of Apollo workstations by the Chemical Engineering Department. Plans to link the TUFFP network with those in the Keplinger Engineering building on the main campus are currently underway.



Two Phase Flow Calendar Given

Numerous conferences are scheduled in the coming months which include technical sessions involving multiphase flow in pipes. A calendar of these events is given below and more detailed descriptions appear elsewhere in this Newsletter.

Date	Event	Location
Aug 4-7	Mathematical Modeling Conference	St. Louis, MO
Sept. 27-30	SPE Annual Fall Meeting	Dallas, TX
Oct. 22-23	PSIG Meeting	Tulsa, OK
Oct. 26-27	Multiphase Flow-Technology and Consequences for Field Development	Stavanger, Norway
Nov. 16-20	AIChE Annual Meeting	New York City
Nov. 18	TUFFP Advisory Board Meeting	Tulsa, OK
Nov. 19	TUALP Advisory Board Meeting	Tulsa, OK

TUFFP to Participate in Multiphase Flow Conferences

Research performed by TUFFP personnel will be presented at the SPE Fall meeting, held September 27-30 in Dallas. Dr. Shoham will present a paper on two-phase slug flow metering on Monday afternoon. A paper on predicting temperature profiles in wells with the use of down-hole heaters will be presented by Dr. Brill on Tuesday afternoon. Also on Tuesday afternoon, Stuart Scott, first place graduate winner of the Rocky Mountain/Mid-Continent Regional student paper contest, will be competing in the SPE 2nd International student paper contest.

TUFFP has agreed to participate in a conference titled *Multiphase Flow Technology and Consequences for Field Development* in Stavanger, Norway October 26-27. The Conference is sponsored by the Norwegian Petroleum Society and will contain several extremely interesting papers on actual field experience, development of two-phase flow facilities for future fields and critical

areas for research and development. Dr. Brill will present a paper on slug flow and growth in gas and oil pipelines based on data obtained in Prudhoe Bay whose analysis was included in the Ph.D. dissertation by Stuart Scott.

Two sessions on Multiphase Flow in Pipes will be included in the 1987 annual AIChE meeting in New York City, November 16-20. Dr. Kouba or Dr. Shoham will present a paper titled *A Model for Gravity Induced Drift in Intermittent Two-Phase Flow in Horizontal Pipes* at this meeting.

One session on Mathematical Modeling in Multiphase Flow and Heat Transfer will be held at the sixth International Conference on Mathematical Modeling August 4-7 in St. Louis, MO. Dr. Shoham will present a paper on August 5 titled *Modeling Transient Two-Phase Slug Flow* based on Dr. Sharma's Ph.D. dissertation at TUFFP.

Advisory Board Meeting to be Held November 18

The 1987 annual TUFFP Advisory Board meeting will be held at the Sheraton-Kensington Hotel in Tulsa, Oklahoma on Wednesday, November 18. The meeting will begin at 8:30 a.m. and adjourn at 4:30 p.m. A pre-meeting cocktail party will be held at the Kensington Hotel from 5:00 - 7:00 p.m. on Tuesday, November 17. Tours of TUFFP test facilities will be held Tues-

day afternoon from 3:00 - 4:30 p.m.

The above meeting date was selected to accommodate those member companies who will also attend Advisory Board meetings of other cooperative research programs at Tulsa University the same week. Following is a summary of these meetings.

PROGRAM	MEETING DATE
Erosion/Corrosion Research	November 16
Drilling Research Projects	November 17
Fluid Flow Projects	November 18
Artificial Lift Projects	November 19

An Advisory Board Meeting brochure will be mailed to all members prior to the meeting. It will contain sufficient information to prepare each attendee for active participation in discussions on current and future research projects, financial matters, and operating procedures. A brochure containing slide copy for all presentations will be distributed at the meeting.

A REQUEST FOR INFORMATION form will be mailed to all members on October 1, 1987 to determine attendance at the meeting. The form will be accompanied by information pertaining to the Sheraton-Kensington Hotel reservations, accommodations, and transportation to and from the airport.



Personnel Status



PETROBRAS plans to send two students to TUFFP to work on Ph.D. degrees in Petroleum Engineering. An application has been received from **Ibere Nascentes Alves** to begin his studies in September, 1987. **Kazuioshi Minami** hopes to begin his Ph.D. program in January, 1988. Mr. Alves completed an M.S. degree in Petroleum Engineering at UFOP in Brazil and Mr. Minami completed his M.S. degree at TUFFP. Discussions are also underway with Mr. Dimitri A. Papadimitriou of Indonesia, who is currently an M.S. student at Tulsa University.

Arthur Corcoran graduated in May, 1987 with a B.S. degree in computer science. He is continuing his work with TUFFP until August, 1987. In the fall, he will start to work for the Computer Science Department at The University of Tulsa as a graduate teaching assistant.

Cliff Day, a computer science major, will be returning from a summer at Lawrence Livermore National Laboratory to join the System 87

team in the fall.

Lorri Jefferson, also a computer science major, was employed as a part of the System 87 team this summer. She will graduate in May, 1988 and is planning on attending graduate school the following year.

Teeradetch Tungsubutra, a junior petroleum engineering major from Bangkok, Thailand was employed by TUFFP this summer, working as an assistant to Srihasak Arirachakaran and the TUFFP technicians.

Tony Chan, a chemical engineering student who recently completed his M.S. degree in May, also worked for TUFFP this summer as an assistant to Guohua Zheng and the technicians. In September, he will begin his Ph.D studies at The University of Tulsa.

Guohua Zheng, who is currently working on his M.S. in petroleum engineering will continue working for TUFFP while he completes his Ph.D.



Financial Status



Two members have not yet paid their 1987 membership fees. In one case, the company has only recently been invoiced and in the other a request has been submitted for immediate payment.

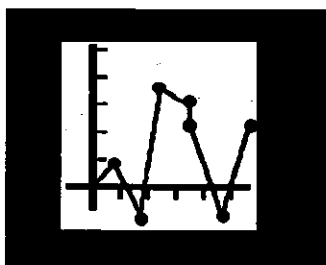
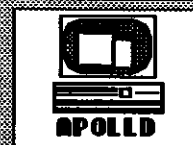
The revised budget prepared for the May, 1987 Advisory Board meeting anticipated a Reserve Fund balance at the end of 1987 of \$14,541. However, this budget also assumed that one new member would be obtained during 1987. We have been unsuccessful in obtaining a confirmed new member. This, coupled with addi-

tional expenditures for equipment and professional salaries, will result in a deficit rather than surplus by the end of 1987.

Invoices for 1988 membership fees will be mailed to member companies on October 15, 1987. The membership fee for 1988 will again be \$14,000. Any new members obtained will pay an additional information fee of \$10,000 unless they are reinstating past membership that has not lapsed more than five years.



System '87



TUPLOT

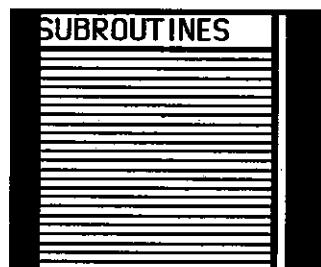
Much time has been spent establishing format and standards for this TUFFP semiannual newsletter. A desktop publishing program entitled *Ready, Set, Go!3* by Manhattan Graphics and Letraset is being used for this project.



L. Jefferson

The TUPLOT subroutines have been converted to the System '87 standards and are now complete. Three new subroutines have been written this summer: **AXIS**, **BOX**, and **FRAME**. **AXIS** draws one labelled axis according to the size specifications given by the programmer. **BOX** closes the X and Y axes and subsequently plots into a box. **FRAME** simply draws a large box around the whole plot and is an alternative to **BOX**. The TUPLOT subroutines have been tested and appear to be working fine for the test data used. Extension of these subroutines to allow plotting on an Apollo screen is now starting. Preliminary work using the CORE graphics standard by Arthur Corcoran indicates that this extension should be straight forward.

Future plans involve the completion of a software review of *Ready, Set, Go!3* this summer and of *Cricket Graph* this fall.



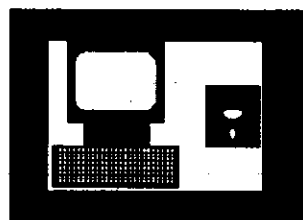
CORE

An extensive testing of the new version of the PVT and GRAD routines has just been completed. In addition, the TUPLOT subroutines have also been included in the CORE manual. Distribution of manual and source code to TUFFP members is scheduled for September.



F. Kung

The software review of MathWriter, a mathematical typesetting program, has been put into its final form using the desktop publishing software entitled *Page Maker*. It has also been submitted for publication in *SPE MICROCOMP NEWS*. A software review of *Page Maker* is scheduled for completion this summer.



Miscellaneous

A new interface board has been purchased for the Harris line printer and is now operational in the Apollo network. Work continues on installation of Dr. Kouba's data on an IBM-PC-AT and compacting it for shipment to him in England. Transfer of the data from magnetic tapes, to the Apollo network, to an IBM-PC has been slowed due to the large amount of data (~35 Mbytes) and our limited disk space.

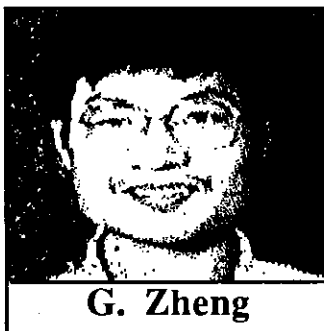


Research Projects



Two Phase Slug Flow in Hilly Terrain Pipelines

The flow line has been functioning well since the May, 1987 Advisory Board meeting. Following is a summary of progress on installation and calibration of instruments and facility operation.



G. Zheng

Flow rate metering: Gas flow rates are measured with an orifice meter while liquid flow rates are measured with two turbine meters and one orifice meter. Calibration of the gas orifice meter was performed with a sonic nozzle. The relative error was found to be within 2.5% when an appropriate orifice plate was chosen. In order to calibrate the turbine meters and liquid orifice meter, the load cell on the weigh tank was first examined with a calibration platform. A correction factor of 1.013 was found. The discharge line from the weigh tank was also re-routed so that the operation of weigh tank dumping is easier and safer. Problems were encountered in signal conditioning of the turbine meters. The use of frequency output as a signal source to the computer timer/counter channels failed due to excessive signal distortion developed in the long transmission line from the flow rate metering station to the instrumentation trailer. An alternative is now being tested, using a pre-amplified voltage signal as computer A/D input.

Capacitance sensors: Eight ring-type capacitance sensors are now available. A 2-ft long strip-type capacitance sensor is being made and will be placed in the trap section. All capacitance sensors will be statically calibrated on line. Dynamic calibration of capacitance sensors will be

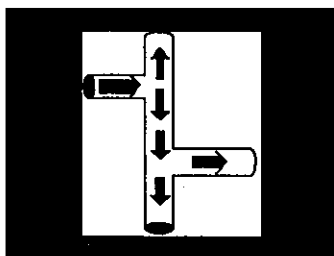
accomplished by trapping slugs between two quick-closing/opening ball valves mounted on the line. Two micro-switches were installed on the trap valves for the purpose of checking time delay in valve actuation. Three versions of a testing program, each utilizing a different detection technique, were written to test the time delay.

Pressure and temperature transducers: Four absolute pressure transducers were calibrated on line by stabilizing the pipeline under different pressures. The calibration curves are exceptionally linear. Trials were also conducted to calibrate the four differential pressure transducers (DPTs) with inverse U-tube monometers mounted on the line. It was found that the diaphragms originally selected for the DPTs were not suitable. The diaphragms will be replaced with 0.32 psi range diaphragms. The temperature transducer (PRTD) was pre-calibrated in the laboratory, installed and is functioning well in the line.

Computer: The IBM PC AT in the instrumentation trailer has been linked with the TUFFP Apollo work station network in the Drill Building. The original hard disk for the AT developed serious problems and was replaced with a Priam 40 MB disk in early June. The new hard disk has an average access speed of 28 milliseconds and is partitioned as two disks with one exclusively designated for data acquisition.

Operation manual: An operational accident occurred on June 23, 1987 in which a damaged plastic valve caused a loss of a significant quantity of kerosene. Sun oil company has agreed to replace the entire batch of kerosene in the storage tank. As a result of the accident, a safety manual was developed to be used by future operators of the flow line. An emergency pump shut off switch was also installed in the trailer.

Data Acquisition: In the process of calibrating instruments, many computer programs have been developed, which include a library of data acquisition routines and a main program for actual test runs. Preliminary test runs are scheduled in mid August. The test results will be presented at the November Advisory Board meeting.



Slug Flow Splitting Phenomena in Side-Arm & Impacting Tees

Construction of the new experimental facility to study slug flow splitting at regular side-arm and impacting tees is underway. Recall that the whole piping system from the mixing tee to the splitting acrylic tee was designed to be raised approximately 6 ft. above the floor. This required that the supporting network for the elevated pipes be completed first. Problems were encountered during the construction of this network due to the variable slope of the floor. Most slope corrections of the supporting network had to be done on site, thus slowing down construction.



Arirachakaran

The decision was made in early June, for safety reasons, to use R-4000 clear PVC pipe instead of acrylic pipe. This makes the process of laying the pipe on top of the supporting beams an easier and straightforward one that should be completed during July. This decision has also saved time since all the piping components are readily available, easily assembled, and need not be machined.

The air section from the air supply valve to the mixing tee, including an orifice meter, has been installed. The liquid section was delayed due to the unavailability of the required turbine meters. It was initially hoped that these turbine meters for metering liquid flow rates would be donated by C-E Invalco. C-E Invalco's metering section has merged with C-E Taylor Instrument, Inc. Negotiations have been initiated with Taylor, but no decision has yet been made. Other turbine meter manufacturing companies are also being contacted.

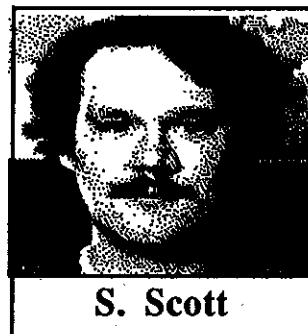
Back-pressure regulators and liquid-level controllers for the separator will be donated by

C-E Invalco. This equipment is expected to arrive in early August. If all equipment arrives as scheduled, the experimental facility could be in operation in September when the data acquisition system interface will be implemented. The first batch of data for slug flow splitting at a regular side-arm tee is scheduled to be collected in October.



Modeling Slug Growth in Pipelines

Long term slug-growth effects have been successfully incorporated into the models. Distribution of the completed dissertation to the PhD Advisory committee is imminent. It now appears that two separate programs will accompany this work.



S. Scott

The first program is for the developing slug growth model, which has been extended to also predict long term slug growth in a mixed Eulerian-Lagrangian manner. This model is tightly coupled with the new slug formation triggering mechanism, and has been shown to be particularly valuable near the stratified-slug transition boundary and for slightly terrain affected flow-lines.

The second program is a stand alone extension of the Taitel long term slug growth model. This model has been enhanced in a number of areas to allow applications in the petroleum industry. In particular, the "Black-Oil" fluid model has been utilized rather than the ideal gas law originally proposed by Taitel.

In addition, the foundations of a subroutine library called MODEL have been established. It features subroutines for calculations useful in two-phase flow modeling. It is anticipated that additional subroutines will be added to this package by other graduate students as they complete their programs.



Severe Slugging in a Pipeline-Riser Pipe System

The severe slugging project is progressing according to the schedule presented at the May Advisory Board meeting. There have been some recent modifications to the dimensions of the riser due to the size of



S. Vierkandt

the room in which the system is being built. Because of the limited ceiling room the riser pipe height has been shortened from 15 feet to 10 feet.

A decision was also made to substitute R-4000 clear PVC pipe for the acrylic pipe that was originally chosen for the system. With the selection of the R-4000 pipe we are still able to observe the severe slugging process take place, plus we have the added safety of a higher burst pressure. Another advantage is that pipe fittings are readily available, thus saving us from custom machining fittings for the acrylic pipe.

By the middle of September the system should be operational and preliminary tests will be conducted. Data collecting and modifications of the existing severe slugging model will be carried out in the Fall semester after Dr. Taitel arrives at The University of Tulsa. Some preliminary results should be ready by the November Advisory Board meeting.



Comprehensive Mechanistic Model for Upward Two Phase Flow in Pipes

The purpose of this project is to develop a comprehensive mechanistic model for predicting flow behavior in upward two phase flow. After its development, the model will be evaluated against the TUFFP well databank.



A. Ansari

For this purpose, the databank will be updated and transformed into an easy-to-use database on the Apollo computer system.

A mechanistic model for bubble flow has been developed and is being evaluated against the data available both in the databank and in other published sources. After its evaluation, the model will be combined with existing mechanistic models for slug and annular mist flows to obtain a comprehensive mechanistic model for upward two phase flow.

At the same time, newly received Prudhoe Bay flowing pressure and temperature surveys from the field of Alaska and other published data are also being studied and sorted. These new data will be used to expand the TUFFP well databank.

Work on these objectives will continue during the Fall semester and preliminary results will be presented at the November, 1987 TUFFP Advisory Board meeting.

1987 TUFFP Members

Amoco Production Co.
 Arabian American Oil Co.
 Arabian Oil Co., Ltd.
 ARCO Oil and Gas Co.
 BP International Ltd.
 British Gas Corp.
 Britoil
 Chevron Oil Field Research Co.
 Chiyoda
 Conoco
 Instituto Mexicano del Petroleo
 Intevep
 JGC Corp.

Japan National Oil Co.
 Midcon Corp.
 Mobil Research and Development
 Nippon Kokan K. K.
 Norsk Hydro
 Pertamina
 Petrobras
 Phillips Petroleum
 Shell Internationale Petroleum
 Statoil
 Texaco
 Texas Gas Transmission Corp.
 Union Oil Co. of California

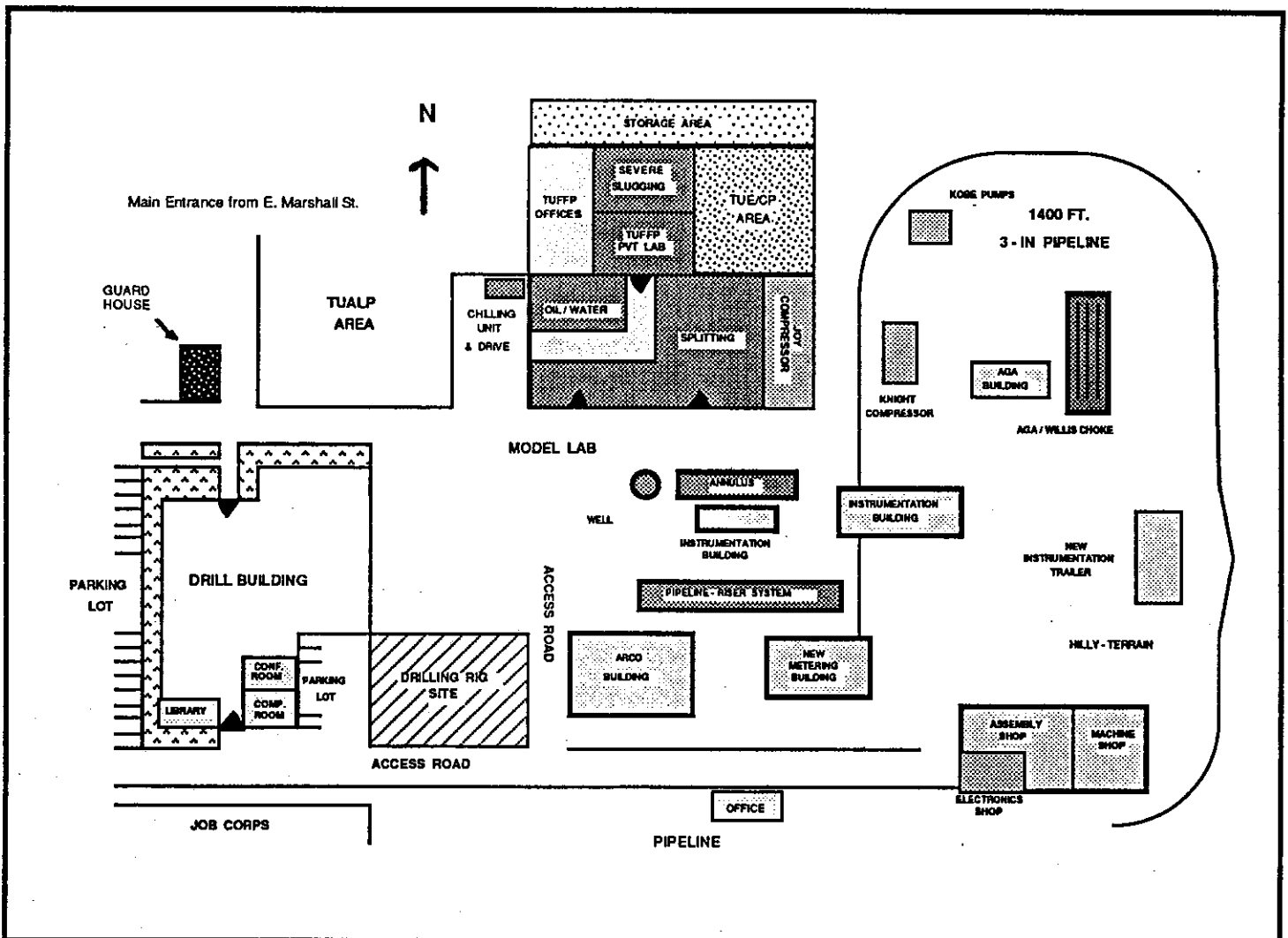


Illustration of TUFFP Test Facilities

