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A Dual Process Computer Control System – Problems and Answers *

By D. J. Fraade
CIBA-GEIGY AG, Basel, Switzerland

and R. C. Smith
CIBA-GEIGY CHEMICAL CORPORATION, St. Gabriel, La., U.S.A.

Abstract

This paper's purpose is to relate the problems—and answers—concerned with a dual on-line process control computer system. Seldom, if at all, is a paper presented that squarely sets out to discuss the user's troubles. This paper hopes to correct this tendency which the authors feel is really a disservice to the technical community interested in this aspect of applying advanced automation methods in modern chemical processing operations.

Introduction

We conclude there are several reasons that people do not willingly relate the troubles and problems they had with their process control computer systems.

One reason is that they may have put their necks out and have reason (valid or not) to believe they may be vulnerable for an axe to fall. But a turtle only makes progress when he puts his neck out.

Another reason is that they may be afraid that others will say: "What's the matter with him? That's no problem. Why we solved that one years ago. Where has he been all this time?" Our company has ordered, installed or has in the works some 45 such systems throughout its worldwide, global operating plants. We specifically want to tell about one of our most "sophisticated" systems because, from a problem-solution standpoint, it offers the broadest spectrum of experiences; both good and bad.

The following text will examine the noted problems areas and will deal in detail with our thoughts and experiences:

1. Historical Problems
2. Operating Problems
3. Maintenance and Service Problems
4. Training Problems
5. Chromatograph System Consultant's Software Problems
6. Financial Problems
7. Experiential Problems
8. Plant Start-up Problems

We finish up with some conclusions and recommendations for the future.

1. Historical Problems

a) Although various parts of this particular herbicide process had been run in other locations, this new plant was, to all purposes, a new continuous process. Notwithstanding, the project inherited the attitudes and prejudices brought along by the people from these other locations.

b) Design and pilot plant work had been going on for a few years before that point in time when the concept of computer control was reached. Hence, decisions concerning instrumentation and control hardware, physical layout, operating methods, etc. all had been made. The computer system concept and implementation had to fit these decisions.

e) The process was a new one and, as such, presented many aspects that were considered too risky to try to solve with computer-oriented solutions.

d) The operation of the process was completely and absolutely dependent upon analytical results. This led to certain constraints in computer concept application and forced an orientation in the direction of the analyzers involved and their effect upon the basic control problems.

e) The feed and product materials in the process are difficult ones; corrosive, toxic, dangerous and hard to dispose of. We start with HCN and Cl_2—and then it gets worse from there!

f) For the process stream analyzers, the sample handling systems involved posed very difficult problems. Some, involved with applications where the key control payout lies, still have not been solved.

g) There was an engineering contractor in charge of the overall project. There was a computer system consulting contractor who supplied a turn-key package for one of the computers. There were the various vendors involved in supplying the basic instrumentation: There were various subcontractors and sub-, sub-contractors involved with the details of erection and installation. All of these had the process computer system as a common denominator, more or less.

* As originally conceived, three articles were to be written about this particular computer control system. The first one, titled "A Look Backward at the 'Gestation of a Digital Process Control System'," was published in *Chimia 25* (1971) 161. This is the second one. The third one is titled "Economics of Digital Control—How, Why and Where—A Case History" and will be published in *Chimia* early next year.

h) At that point in computer technology history, only a few small, minicomputer-type systems had been installed and these only in the light hydrocarbon processing area.

2. Operating Problems

a) The new process is a continuous, once-through pass. Operating personnel properly were concerned with how to make this succeed. Computer system problems were not—and, indeed, could not be—their major concern.
b) A great part of the plant operating personnel were new to the company. Their training in computer system operation, understanding and appreciation had to dovetail into whatever other free time was available.
c) Both by its inherent nature and because it was a new process, there was a basic need for fast, accurate data gathering.
d) The aforementioned dependence on analytical data for successful operation had the plant operators running lab analyses out in the unit. Hence, a need to get ride of these lab methods and replace them with on-line analyzers. Mostly, these were gas chromatographs and subsequent discussion will show how the concept that finally evolved resolved this aspect.
e) For a new process of this type, there were many new instrument types installed. There was 100% analog back-up involved with interacting with a two-computer system.
f) Involved were machines and operating entities (conveying, weighing and packaging) from both the U.S.A. and abroad.

3. Maintenance and Service Problems

a) The dependence upon analytical data and the need to replace lab methods with on-line analyzers both pointed to computerized operation of any such devices. The classical method of handling process chromatographs with a computer is shown in Figure 1. Figure 2 shows the possible communication links in this method. Figure 3 indicates how a dedicated process chromatograph computer system could be conceived. The performance advantages of chromatograph peak data reduction with a computer system have been well known for more than ten years.

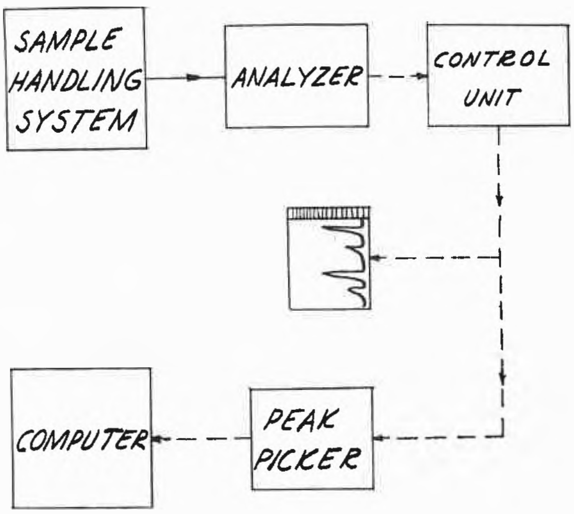

Fig. 1

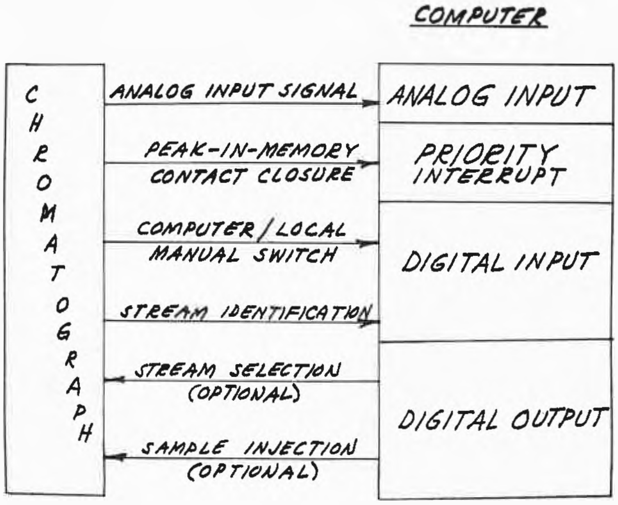

Fig. 2

b) All of this background led to the concept that eventually was chosen. Figure 4 shows this as being a dual computer system—
   (1) an IBM 1130 system that was modified for on-line operation. It handles a total of 42 chromatographs; data reduction on 27 laboratory type (in three different plant locations) and completely controls 15 process chromatographs.
   (2) an IBM 1800 system that does process monitoring, process control and management information reporting.
c) This configuration promised the greatest system uptime and instrument availability. However, to achieve these goals it was recognized that the people aspect would be a major problem. Hence, we saw the need to be independent of contractor and supplier service people and remove them from the scene as soon as possible. To implement this, the company hired *into the computer project group* an analytical instrument specialist. His was the task of taking over the checking out, interfacing, field installation, trouble shooting and commissioning these instruments. He also trained the plant instrument maintenance people in the computer-analyzer aspects.
d) Because of the need for analytical data, the continued running of the plant—even with the 1130 chromatograph computer down—necessitated some means of affording the operators process chromatograph data. "A Man/Chromatograph Interface" was the answer. Figure 5 shows the 1130 chromatograph

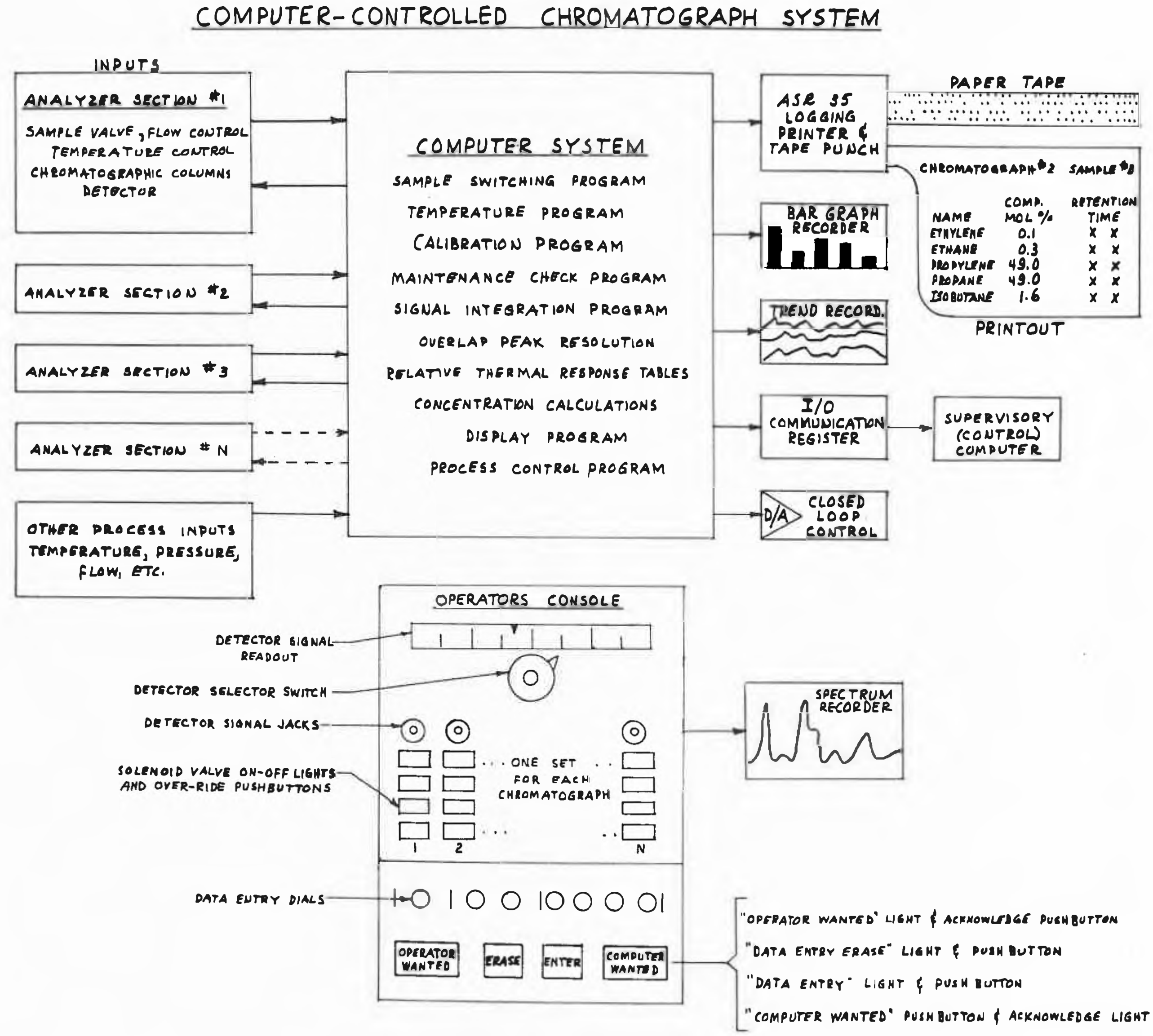

Fig. 3. Computer-Controlled Chromatograph System

computer array. The computer is in the middle, the input-output signal interface is on the right and the "Man/Chromatograph Interface" is on the left. Figure 6 is a detail of the M/C Interface. However, we had a "good" problem with this device. Because the 1130 system had had a 99 + % uptime (CPU 100%), it never has been used as originally planned; i.e., as an emergency device to bring in process chromatograph data, albeit on a one-by-one basis. – It has been impossible to keep the operating people trained on it. Hence, it has been used solely as a maintenance and calibration tool. Further, the operating personnel have become so "hung up" on the printed out analysis reports in engineering units, that the conventional chromatogram presentation on the strip chart recorder could not be used anyhow.

4. Training

a) We were fortunate to have enough time to train all personnel involved with the computer system. Unfortunately, this was because of unavoidable delays in the plant construction schedule. To best utilize this "bonus" time, we had to get the systems installed and into operation so that we could, indeed, provide a training program. Again, we were lucky to find exceptional facilities at Gulf South Research Institute near to the new plant. – Figure 7 shows in the left-hand foreground some lab GLC's hooked up for testing.

b) To be able to provide realistic signals for program debugging, provide "hands on" training and do the necessary receiving inspection and testing—all on our 15 process chromatographs—these instruments

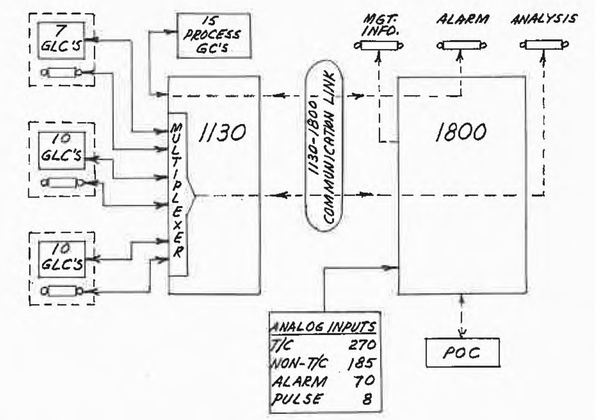

Fig. 4

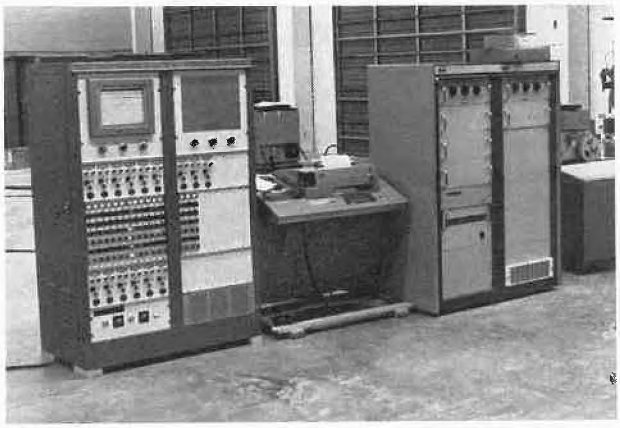

Fig. 5

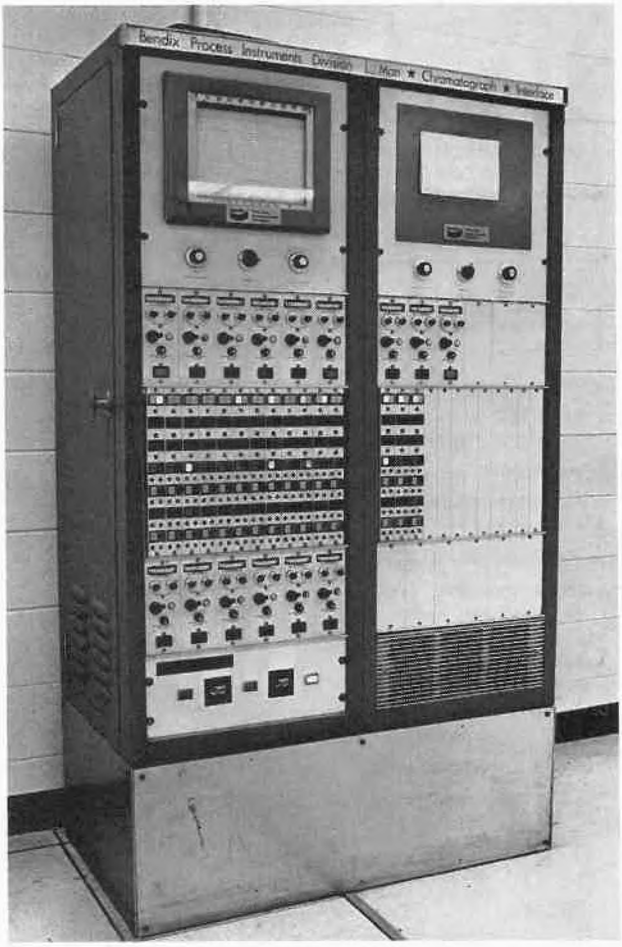

Fig. 6

Fig. 7

were delivered to us at the institute. Many things were turned up here and we were able to note these, correct what we could and have the supplier do the rest before the instruments were sent along to the plant for final field installation.

c) We further attempted to simulate plant conditions as much as possible for both the process and lab chromatographs. In this way both the plant maintenance people and lab technicians had ample time to learn the systems, change and refine methods and get acquainted with these new blue boxes.

d) Also involved with this training phase before installation at the plant were normal high and low level analog inputs, analog outputs (control signals) and digital inputs and outputs. Again, the time bonus available to us had to be put to good use. We had no plant instruments there. So, we used simulators, or signal generators, to provide dynamic signals capable of being changed throughout their expected ranges. – There, again, we brought the plant operators in for training sessions and used our simulators to range signals in and out of alarm limits, showing how the computer scanned these, alarmed those out of limits and took applicable corrective control action as required. – This paid off handsomely later during start-up and subsequent operations. The plant people knew how the computer system was to work; they understand how to command it for data they required and, finally, they appreciated what the data meant. – Figure 8 is the analog input signal generator composed of potentiometers (two signal levels; mv and volts) and a digital voltmeter display. Figure 9 shows the digital input-output signal generator. The inputs are triggered by toggle switches and the outputs are indicated on small lamps.

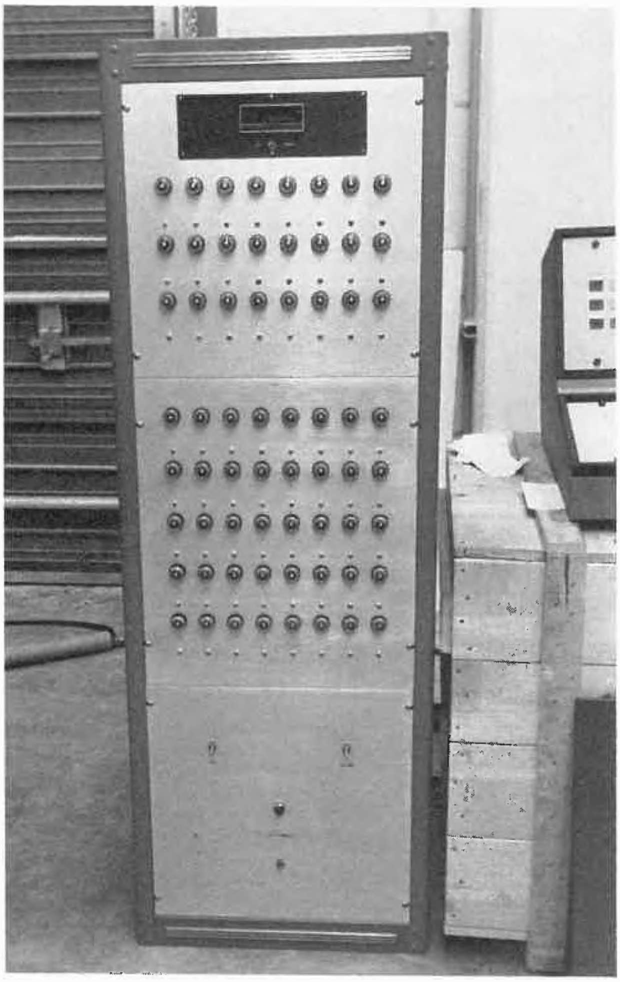

Fig. 8

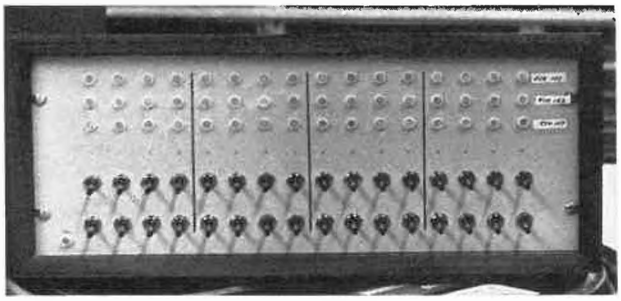

Fig. 9

5. Software

a) One major problem was the inflexibility of "standard" packages we purchased as a turn-key contract the standard lab GLC packages.

b) However, we immediately needed almost major overhauls to include:
- wet chemistry analysis entry
- digital outputting for control of process chromatograph functions
- handling negative peaks from gas density balance detectors
- communicating results to 1800 computer system.

The consultant's regular software had to be modified to incorporate these required features. This meant taking the standard function modules apart, writing the new program blocks and then weaving them all back together to work, hopefully, successfully.

c) If this was not enough of a problem, we also had to have the 1130 transmit analyses to the 1800 to be used for control calculations, material balances and reporting. In addition, diagnostics of only the process chromatograph results were to be done by the 1800, rather than by the 1130. Properly, they should have been done by the latter, but this would have meant more major cutting up of the standard 1130 softare. In turn, even longer delays and interaction problems. So, the 1800 was programmed to look at the elution time and value of the selected peaks. If one was out of either limit, an alarm message was printed that such an analysis was no good, followed by a printout of the entire analysis. For control purposes, the 1800 used the last valid analysis held in memory.

d) As in any such project, continuity of personnel is of prime importance. People turnover cannot be guaranteed against. However, every effort should be made to work with people who can remain, more or less, locally on site. New people coming in on the project have to be oriented and brought up to speed, necessitating time to figure out just what his predecessor had been trying to do.
e) Another problem area already mentioned was the lack of proper diagnostics to check out completely the final software, including the aforementioned modifications. This lack of comprehensive diagnostics resulted in our having to work in fits and starts, with a lot of time spent in detail digging into errors which, had diagnostics existed, could have been done easily and in a lot less time.
f) The guaranteed system design capacity was another problem area. It still is hard to say whether it is software, hardware or both. This problem manifested itself in the appearance of what looked like noise whenever the maximum capacity design limit of the system was reached. Only it was not noise. When the plant was not running and the chromatograph burden was reduced, the system worked fine. It was almost as though the system had a mind of its own and would not be pushed to its design limit.

6. Financial Aspects

Perhaps these considerations are not the same kind of problems as such, but they were the bases from which the concept evolved. The concept grew out of a feasibility study which recommended this dual computer idea because it could be justified and amortized financially.

a) Direct savings on expenditures not made came from:
   1. strip chart recorders for process chromatograph at $ 1000 each × 15 = $ 15,000
   2. process chromatograph "black box" programmers at $ 2000 each × 15 = $ 30,000
   3. peak pickers for conventional process chromatograph systems at $ 1000 each × 15 = $ 15,000.
b) Maintenance on process chromatograph systems in that area of the country run about $ 10,000 per year per system. This figure was quoted by several chemical plant operating companies with whom we checked. As is well known, this cost covers the usual routine periodic maintenance. However, the computer could be programmed to perform diagnostic routines (e.g., normalizing) that could reduce the usual *routine* periodic maintenance. Conservatively, then, this cost savings was calculated at $ 5,000 per year per system; $ 5,000 × 15 = $ 75,000. – These savings, then, total $ 150,000 for the first year and also include a rough estimate of $ 15,000 in panelboard space savings, resulting savings in control room size and elimination of maintenance on entities that were *not* there. The 1130 chromatograph computer system turnkey price was quoted at $ 140,000. This calculated out to be a payout time of 3.2 years after all aspects had been considered.
c) A more indirect type of savings resulted from the ability to reduce—by at least one man per shift—the lab analyses made both in the plants and in the labs. This had a value of $ 40,000 per year.
d) "Accurized" data (integration, etc.) was made possible by the computer approach to handling analyzer results. This allowed for closer and more precise control—and that's where the payout is! The particular analyses on the streams in this plant are such (peak shape, tailings, area allocations, unresolved peaks, etc.) that conventional peak height methods and mechanical integrators could not handle the results satisfactorily.
e) Planning ahead and keeping the concept dynamic involved incorporating additional analyzers in the future. With the ultimate capacity in view, with such a computer system it is much cheaper to do this; it becomes a software problem only of building data files later on for the new instruments.

7. Experiential Problems

a) Disagreements and later new interpretaions of contractual commitments could have been more of delay had not the company bent way over backwands in accepting a vendor's position to keep moving along.
b) The computer project team's analytical instrument specialist was one of the best investments made in terms of insuring successful operation of our system (analyzer results-oriented) and in providing training for the regular plant instrument maintenance people. After commissioning and settling down to normal operation, this technician was transferred into the Analytical Group.
c) We learned that you must stay flexible in your developing and using your analyzer methods. Don't fall too deeply in love with any one of them. It hurts all the more when you have to change them—and change them we did to provide, for example, valid verifications of process chromatograph results.
d) A non-problem aspect we experienced was the ease with which quality control lab technicians learned simple conversational mode programming. They proved invaluable in helping to debug the process gas chromatograph operations.
e) Another expected problem area also turned out to be a non-problem area. We thought that the run-of-the-mill production operator would be floored by the concept of computerized data from the chromatograph analyzers. To the contrary, he uses the 1130 system easily and comprehensively to follow his processing operations.

8. Start-Up Problems

a)
By and large, this whole area reduced itself into the question: "Who has the ball?" Was any particular difficulty or problem at any one instant in time the responsibility of the production people, computer team, quality control group or maintenance?
To prevent this initial lack of communication from becoming a catastrophe, a detailed list of tasks was mutually drawn up, decided upon and then specific groups were assigned to each.
The first phase meetings produced the following list that attempted to define the process analyzers' functions:

1. Determination of Need
2. Economic Justification
3. Technical Feasibility
4. Applications Development
5. Sample System Development
6. Specification and Selection of Instrument
7. Engineering for Purchasing and Installation
8. Physical Installation
9. Start-Up of Instrument and In-Plant Checkout
10. Mechanical Maintenance
11. Application Maintenance
12. Plant Surveillance

Within the Technical Department, of which the computer project team was a part, were also a process engineering group and a project engineering group. An analysis was made of their resources to determine how these could be used during this critical start-up phase.

Computer Control Croup

1. Detailed knowledge of process gas chromatography with field maintenance experience.
2. Extensive electronic experience.
3. Knowledge of the details required for interfacing most analytical devices (and other instruments) with the computer.
4. In addition to the above, this group has prime responsibility for operation and maintenance of the entire computer system.
5. The group has two laboratories designed specifically for use in process analyzer development. One laboratory is in the Technical Building, and the other is in the Maintenance Building.

Process Engineering Group. This group has prime responsibility for process maintenance (trouble shooting and Technical Service) and as such will continually be surveying the plant for areas of improvement as well as solve problems related to the process. With this charge, these people will be in an ideal position to determine (with Production) fruitful areas for investigation of analyzer needs. In fact, all analytical needs will be of great concern to this group. Much of the ability to economically determine the feasibility for installation of any type of process control, including analytical methods, will exist within this group.

Project Engineering Group. This group contains the capabilities for handling the many details of engineering and installing relatively exotic devices into the plant. They are familiar with all existing instrumentation and electrical systems. They prepare cost estimates and requests for capital expenditures. They are responsible for any design additions of changes to the physical plant property. – Together, then, with all of the other departments, the Table of Responsibilities in Process Analyzers was finalized as shown in Figure 10.

RESPONSIBILITIES IN PROCESS ANALYZERS

	TECHNICAL					
FUNCTION	PROCESS	PROJECT	COMPUTER	ANALYTICAL	MAINTENANCE	PRODUCTION
DETERMINE NEEDS	1		2	1or 2		1
ECONOMIC JUSTIFICATION	1		2	1or 2		1
TECHNICAL FEASIBILITY			1	1		
APPLICATION DEVELOPMENT			1	1		
SAMPLING SYSTEM DEVELOPMENT			1	2		
PROTOTYPE (IF REQUIRED)			1	2		
SUBMIT CAPITAL AUTHORIZATION		1	2			
SPECIFICATIONS		1	1			
ENGINEERING AND PURCHASING		1	2			
LAB CHECKOUT (IF NEEDED)			1			
INSTALLATION		1	2		1	
STARTUP AND PLANT CHECKOUT			1			2
MECHANICAL MAINTENANCE					1	2
APPLICATION MAINTENANCE	2		1	2	2	2
PLANT SURVEILLANCE	1		2			1

1 - PRIME RESPONSIBILITY
2 - SECONDARY RESPONSIBILITY

Fig. 10. Responsibilities in Process Analyzers

b)
Further communication problems during this phase was the lack of same between the various parties involved; vendor, contractor and cosultant. For example, it is easy to imagine how many wires had to be pulled and connected up in such a dual computer system. Yet, strangely enough, there were not signal wiring errors, only power supply and grounding errors.

c)
This aspect leads us directly into the area of documentation. Having so many different groups all working around the computers could have led to a Tower of Babel situation concerning detailed drawings. It was impossible to impose one common documentation scheme or format on all of these different groups. Too, data needed by one to complete his drawings more often than not was not available at that time. This put the onus on the computer and instrument engineering groups to get acquainted with all of the different documentation and to act as a sort of clearing house and information bureau for all concerned.

d)
Taking a careful look backwards, such problems came close to destroying the confidence of the people (production operators and lab technicians) who were to use the system. That this did not occur was due to long and

early training. The resulting confidence build-up took them up to a peak where the problem destruction factor could not prevail. In addition, getting the problems answered did the trick.

Conclusions for the Future

How many times it has been said "Oh, if we had to do it all over again ..." Well, we are no different and so, here we go—

a) We might possibly conceive of a simpler computer system using simpler computers. At that time, as stated, very little experience existed with the smaller mini-computers. Our corporate stance is that we favor (all things being equal) such dedicated small machines. Of the computer systems we have in the mill now, more than three-fourths are of this type.
b) To be recommended, certainly, is not buying from a vendor who does not have truly developed, tested and debugged "standard" software. Our computer systems specifications and quote requests all include such a provision as a basic requirement. Extensive modifications of such packages for specific applications caused many of our troubles in this area.
c) We would not repeat a job where the responsibility was so split up and parceled out. Our experience has shown us that our own people best execute the control of the project.
d) Linked to this multi-party situation is our belief that all contractors should be gotten off of the site as soon as possible—if not sooner.
e) We see now that we held to unrealistic goals and schedules that did not reflect the changing times during which the work was implemented. We now would know to build in more flexible factors. However, this was the first project and so we were too severe and over-cautious We see now that this holds true for implementing future phases.
f) Indeed, we currently are expanding the computer functions to other areas in the plant and will add new analyzers because of the proven success of the 1130 system.

One question we do keep asking ourselves as applicable, at least, to our domestic operations – "Why not more systems?" As a framework for this question we point out that the 1130 system is dedicated to chromatographs and now processes up to 1200 analysis runs per day.