HARD COPY DISPLAY

DR. A. RAYMOND BOYLE: This morning we are going to talk about hard copy output. This is, I think, an interesting phase. Of all of the areas of automated cartography, hard copy output has for a number of years been the most professionally operated part on a production basis. We have been using Gerber 32 plotters with light heads, Kongsberg plotters, et cetera, giving very, very high quality outputs, but very, very slow. That is the main thing. They are expensive but slow. We have had to look at other methods of getting hard copy out. And, of course, getting a scanning output is one of the important processes in this. We have a number of people on the panel this morning with the expertise in this area. I do not think it is at a final stage as far as cartography is concerned, but it is getting to a very advanced state.

I am very anxious to learn more on this subject from the people here this morning. We are going to start off by asking Norman Smith to come to the panel. Norman Smith is from the National Ocean Survey. As far as I know, he is the only person in a production operation of maps or charts, in his case, using a scanning process. It is the MBA information systems scanner. I have seen it in operation. He will tell you about his expertise and experience in this area, the good and bad things that he has encountered. So, Norman, if you would take over the microphone, please.

MR. NORMAN SMITH: Good morning. Thank you very much, Dr. Boyle, for the observation that we are operational with our system. We at the National Ocean Survey sometimes call our approach to the automated cartography problem the "crowbar" approach in that we have a reasonably small budget, and we have to make everything that we do purchase, work and produce an output product to satisfy a production need. This approach also trains our manual cartographers and other people in the system to the fact that they need to contribute heavily to the development of these systems. A little background. The National Ocean Survey produces nautical charts for the boating public, for commercial shipping, and also for other Government agencies. We have on issue some 1,000 nautical charts. Our problem is a limited budget to produce the color separation overlays for these charts on a timely basis. I think that the subject was referred to earlier in the discussions as the impetus behind the conversion to automated cartography.

I would like to say a couple of words about the overall automated cartography system at the National Ocean Survey. Back in the early and mid-sixties, the field acquisition systems were automated on our fleet of ships to provide digital data for hydrographic surveys. In the late sixties we purchased conventional vector flatbed plotters and started building an overall programming system to output a chart image, including symbology and line work, and resolve all the other problems involved. In the early seventies we purchased a five-table digitizing system to convert to digital form the data that were coming in in graphic form from other Government agencies. Our data come from many different sources other than our own field acquisition systems. There is a contract under way at the present time to build a digital data base for all of our published graphic data.

So, you can see that we have a total system--from data acquisition to the final product. Of course, what I am going to talk about right now is the output device, the raster plotter. As Dr. Boyle said, we went out for a raster plotter because of the inherent speeds achievable by this technology. Using a conventional flatbed plotter system to produce color overlays for some 1,000 charts per year, which is one of the goals of the agency, and to re-publish those charts on an average 1-year basis, which is quite a bit more often than they are being published at the present time, it turned out to be uneconomical to do that task with conventional flatbed plotters because of the extreme times involved per plot. So we issued an RFP for an output device. MB Associates, Information Systems Division, here in the Bay Area, came in with a proposal to design and construct a high-speed raster plotter system, which we designated the Nautical Charting Automated Plotter (NCAP). The fundamental requirements for the system were that it was to operate as an off-line stand-alone system, much like the conventional flatbed plotters, and would use our existing computer facilities for software development and support. The production requirements dictated that we needed a maximum 1-hour plotting time for a color overlay, regardless of the complexity of the overlay. And, of course, retaining high resolution and high accuracy, better than that of the flatbed plotters, so that we could get good registration between color separation overlays and be consistent with our National Ocean Survey charting standards. We wanted to have the recording on a commercially available stable base material. By that I mean, we did not want to get into special order films or anything of this sort. We are plotting on a commercially available Kodak Estar base reproduction film which our standard manual reproduction system is using for publication negatives.

As delivered, the system has lived up to those requirements. The contract called for the raster plotter hardware; a software package consisting of user routines to perform linear, cubic, and circular interpolations of data points; symbolization; interior fill of irregular areas; and two special purpose programs--one to build the symbol table, and one to convert our standard flatbed plotter tapes to raster format. And, in addition to that, two raster processing routines to do the lineal to raster conversion. Could I have the first slide, please (Figure 1). This is a picture of the system at the factory. It does not look like that in our establishment. On the right-hand side you can see the control computer that drives the system. It is a NOVA 820 computer system with disk storage and magnetic tape input for the drive tape. In the second bay over is the drive unit for the Spectra-Physics laser, which is the light source in the plotter. At the far left is the plotter cabinet with the doors open, showing access for mounting film to the drum. The computer system operates under a disk operating system (RDOS) which allows us to update programs and drive the system. The input tape, as discussed earlier, is in run length encoding for data compaction. Run length encoding specifies total consecutive on or off raster elements for a specific raster line (2 on, 100 off, 5 on, etc.).

The basic specifications of the plotter are accuracy of plus or minus 0.001 inch; a raster count of 800 lines to the inch in both the X and Y dimension; and a full plot size of 42 inches by 60 inches, which corresponds to our lithographic plate size for printing nautical charts. As stated earlier, we are plotting on 0.007-inch thick or 0.004-inch thick Kodak Estar base reproduction film. We have a circumferential correction for the thickness of the film, as someone mentioned earlier. There is some 0.014-inch error involved there if you do not correct for the thickness difference of films. Could I have the next slide, please (Figure 2). This is not as pretty a slide, but without the cabinet on the unit. The laser is located horizontally underneath the table. The beam travels toward you on the left-hand side and then travels through a series of two electro-optic modulators (EOM) which perform the shuttering of the beam, if you will. Then it is directed up through the table by turning mirrors, down parallel to the drum axis, and then to the beam forming optics, which are on the left-hand side up there. The drum rotates at 600 rpm, and the plot is completed by plotting a raster line around the circumference of the drum, one rotation at a time. The carriage carrying the spot-forming optics is impulsed during a dead part of the drum, and the next line is plotted in that fashion. A full plot takes about 1 hour.

You see a lead screw arrangement for the optical spot-forming optics, but the position is actually optically encoded to a photo etched linear scale. As the drum rotates, the pulses to plot on the film are clocked out by a precise optical rotary encoder mounted to the drum axis. Next slide, please (Figure 3). This is just a test plot that we put out. I would like to display a couple of these just to show you what kind of quality the system yields. This is just an array of vectors to observe the behavior of the software at all different orientations. Next slide (Figure 4).

This is a blowup of actually two sections of that preceding slide. You can see the break in the middle of the slide. On the right-hand side, looks like about the fourth line in from the center, is the straight line in the direction of rotation of the drum, which, as you can image, would be a very straight line. You see the stepping effect of the raster. I think you have seen this on some earlier slides and in some of the other discussions. Each of those steps, again, is one eight - hundredth of an inch, or one and a quarter mils (0.00125 inch). On the left-hand side is the same thing, 90 degrees away, such that the straight line in this case is plotted one dot per revolution. So you can see the repeatability of the system.

Next slide, please (Figure 5). I would like to get into a few of the products that we are plotting on an operational basis. This is what we call a channel tabulation, which informs the mariner of the controlling depths for an entrance channel to a port or other area. We had been plotting these for a number of years on conventional Calcomp flatbed plotters using a scribing tool. We have converted these over to the raster plotter for a couple of reasons. The image is much better than the scribed image and requires much less manual editing when the plot is completed. Also, this gives us a good opportunity to wring out the raster software and operate the plotter in a production mode with all the pressures of production schedules and users that may not understand the complexity of what we are doing.

I will mention some computer times, which, again, have been referred to as "not cheap." We are running our software on a 360/195 at the NOAA installation in Suitland, Maryland. An image like this is using about 1 to 2 minutes of CPU time on that system. It includes about 150 to 200 linear inches of line in an image like this. We are at the present time running about 40 of these per month on a production basis. We have been running since April of 1976.

Next slide, please (Figure 6). This again is another product that we are running operationally. This is a facility tabulation, a listing of facilities available at marinas that is printed on the cover of our small-craft charts. Something like this typically takes 3 to 4 minutes of CPU time to run, and contains 4 to 5 linear inches of line work. We are running on the order of 5 to 10 of these a month on a production basis. A negative image is plotted by a simple change of film. We are not doing anything in the software to convert from a positive to a negative image.

Next slide, please (Figure 7). There were some comments earlier about nomenclature, or labeling, on the charts. This is a test we are running as to acceptability of lettering from the automated system.

Again, referring to another comment, I appreciate fancy lettering and serifs and all that kind of thing as much as anyone, but it does complicate the process of going to an automated type system. I do not know how many fonts of lettering we have had on our charts in the past, but we are now trying to reduce it to four basic styles. This is a Newton medium font (Figure 7), or very close to it. We are trying to reduce our type fonts to a Newton type letter, which is a single-stroked letter that does not contain any of the fancy serifs or embellishments. What we are doing here in this test is trying to see how far we can go--I do not know how well you can see it on these large letters--they are rounded on the ends, and there is some point at which that is going to be unacceptable. But if we can produce letters in this way, we do have the programming and the experience right now to digitize our labeling as it exists on color separation negatives, enter it into our digital data base, and plot it back out on the raster plotter. We have the program to position the letters and to compose the names. Now we are looking at just what kind of letter we can output that will be acceptable.

Next slide, please (Figure 8). I thought I should at least throw in a little bit of propaganda for the agency. This is really a test of the interior fill software. Because we do not have anything akin to area fill on a flatbed plotter, we are not actually doing anything on a production basis with this, but this is an example of where we took a NOAA seal like you would paste on your window in your car, and digitized it on our digitizing system, and then converted it to plot data for the raster plotter. The top part is a test of that area fill algorithm. Next slide, please (Figure 9). I do not know how well this shows up, but this is to give you an idea of the type of data that we are talking about. This is a little different from the contour data and line data that have been discussed largely up to this point. What we are talking about is largely symbolized data represented by soundings, dotted lines for indeterminate shoreline, and other types of symbolization. There is another kind of interesting aside to this. I cannot see it too well from this angle, but you will notice some kind of irregular lines along the shoreline. This is somewhat of a change from the classical way of showing these data. This represents a ledge area, which in the past has had a very fancy, very nice looking symbol. But this is an attempt to stylize it in a different way, which is much more easily handled by our cartographic programs. In this case we have had that accepted by our management. Although on this particular chart, the negatives were not produced on the raster plotter, we did scribe these on a flatbed plotter, and the chart has been published in this form. So, that is another dimension to this automated cartography thing; there needs to be some change in the basic specifications for a chart. We are doing it on a case-by-case basis. But I would agree with the gentleman yesterday from one of the oil companies who made the point that we do have to produce a graphic that the user is used to seeing to develop our credibility before we can move on to totally different products. I would say that probably in a few years this whole subject of hard copy display could well be something entirely different.

I would just like to present, again, a few computer figures. We have a production chart that we are working on at the present time, which, as is always the case, computer turnaround being what it is, was not completed in time for me to bring an example with me. But I do have a few figures to give you an idea of processing times and sizes. The chart that I am talking about is a full-size National Ocean Survey nautical chart. The final product contains about 14,000 linear inches of line. It is fairly typical. This is a chart that contains a little more detail in terms of depth contours and a little more detail in terms of topographic contours than many charts, but is pretty typical. Included in this are 17 million raster points. We are storing the raster points in four bytes, so that is 68 million bytes of information that we have to process in the computer system to produce the image. Time-wise, on a 360/195, I estimate that we will expend about 90 minutes of CPU time to produce this image. That is quite expensive, but when you figure the manual time involved to produce the same image, the cost is really, even at this stage of the software development, cost effective. I think the advances in array processors which we are actively looking into right now--the Goodyear processor and also the ILLIAC system that I think the tour will go to--will bring software costs down considerably in the next few years and make this a very viable way to produce graphics. I would like to make one other point. The things that we are running operationally at the present time are not necessarily suited that well to a large bed raster plotter. But, again, they do provide us a very useful test-bed in a production environment to wring out the software and also to educate the present system with getting used to working with that type of product.

Thank you very much.

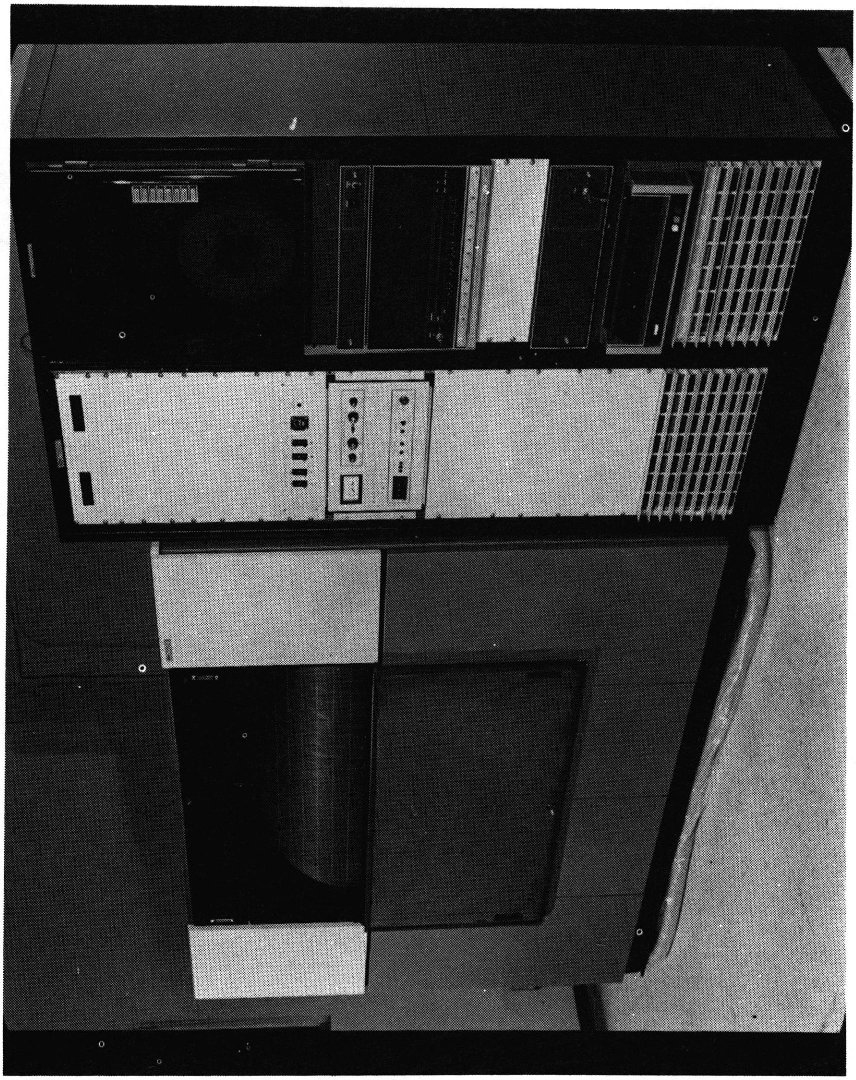

Figure 1

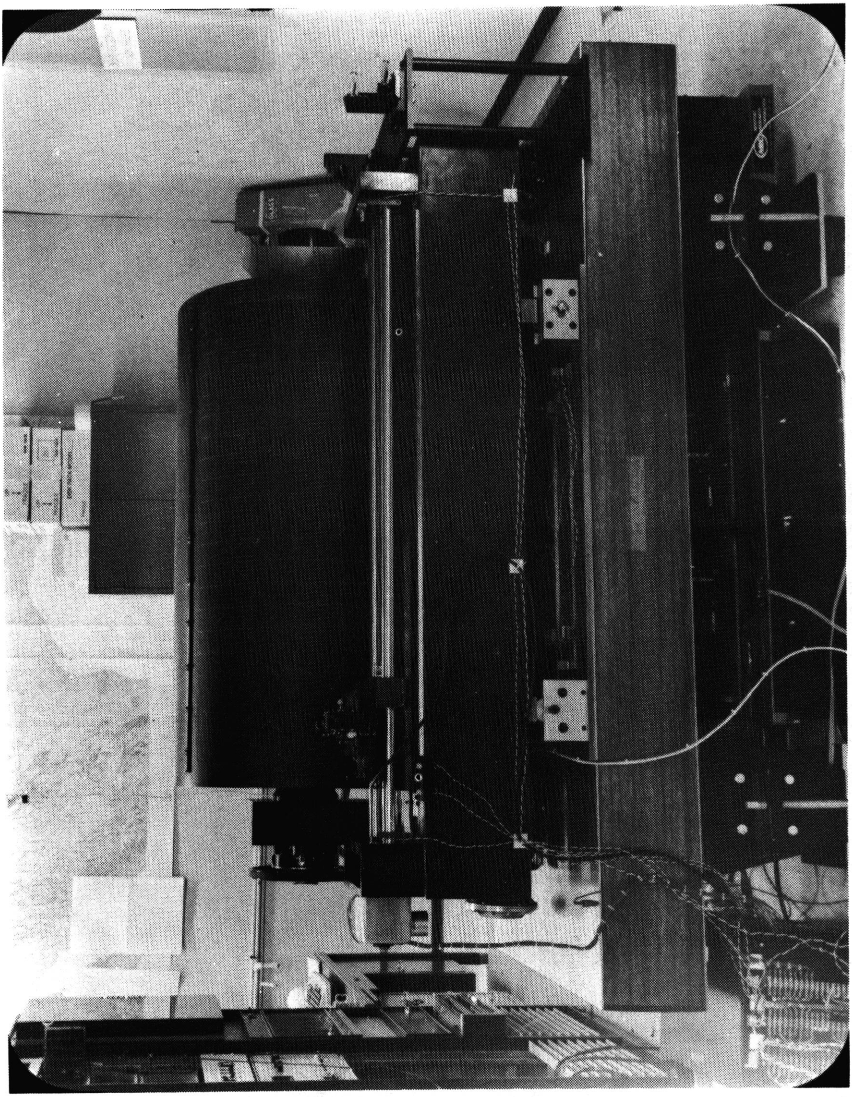

Figure 2

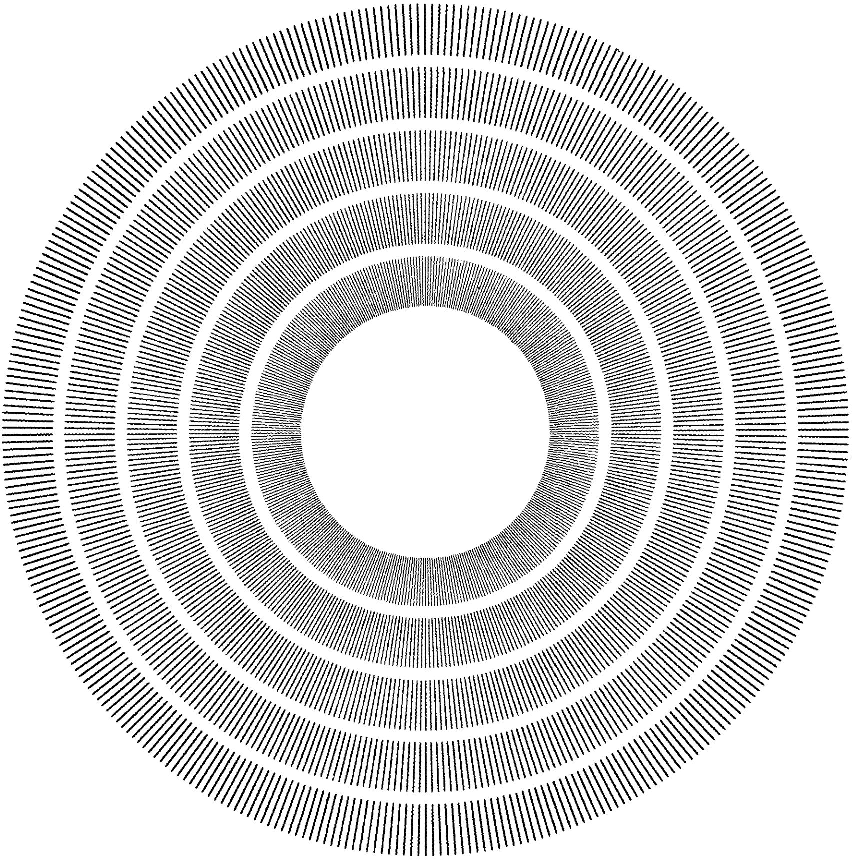

Figure 3

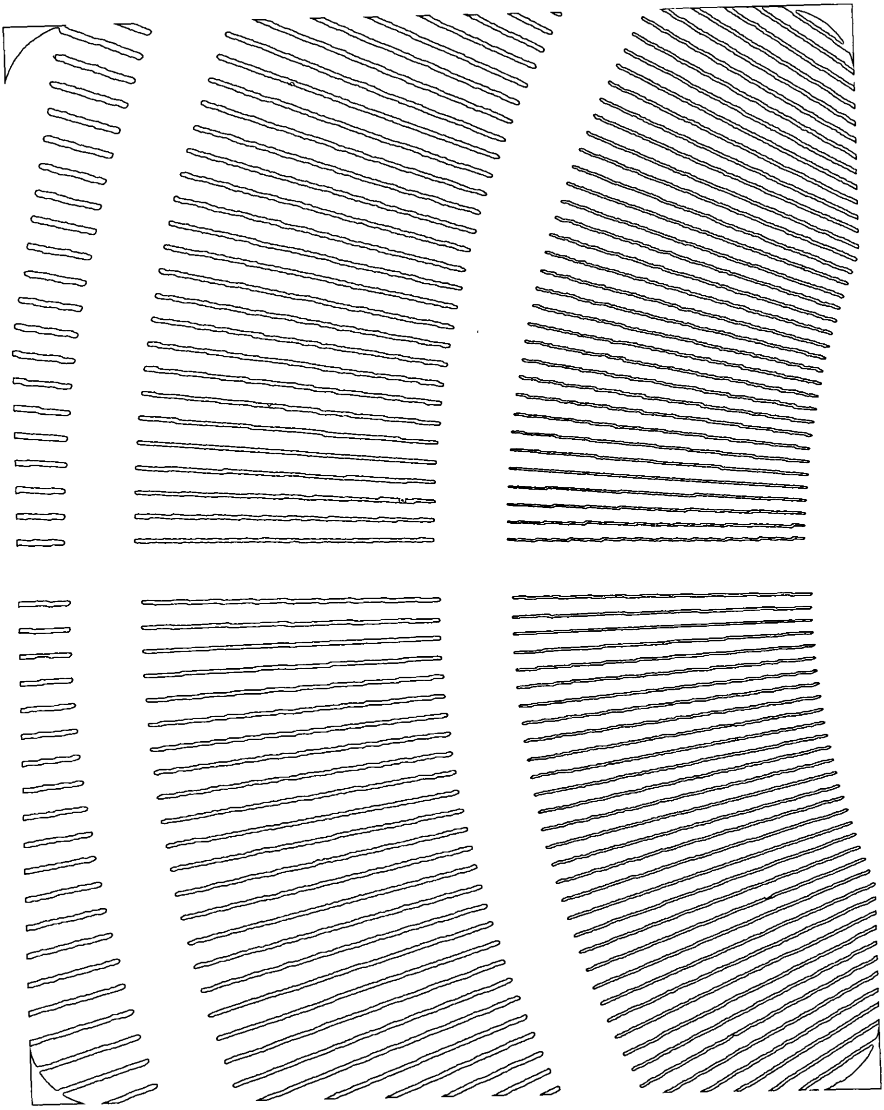

Figure 4

CHART 18447 (C&GS 690 SC)

LAKE WASHINGTON SHIP CANAL							
TABULATED FROM SURVEYS BY THE CORPS OF ENGINNEERS-SURVEYS TO JULY 1975							
* SEE FOOTNOTE					PROJECT DIMENSIONS		
NAME OF CHANNEL	LEFT OUTSIDE QUARTER	MIDDLE HALF OF CHANNEL	RIGHT OUTSIDE QUARTER	DATE OF SURVEY	WIDTH (FEET)	LENGTH * MILES)	DEPTH * (FEET)
SHILSHOLE BAY ENTRANCE RANGE	16 8	31 9	A 7.0	7-75	300-100	1 0	34
LARGE LOCK TO LAKE UNION	25.5	27.5	21.3	7-75	100-300	2.2	30
PORTAGE BAY REACH	24.1	26.8	24.8	7-75	350-200	0 8	30
PORTAGE CUT	27.6	30 1	23.8	7-75	100	0.4	30
UNION BAY REACH	27.0	28.0	19 2	7-75	100-200	0.9	30

A. THE CHANNEL HAS SHOALED ALONG THE EDGE· A DEPTH OF 23 8 FEET WAS AVAILABLE IN THE INSIDE HALF OF THE QUARTER.

* CONTROLLING DEPTHS IN CHANNELS ENTERING FROM SEAWARD IN FEET AT MEAN LOWER LOW WATER BELOW THE LOCKS AND AT LOW REGULATED LAKE LEVEL ABOVE THE LOCKS PROJECT LENGTHS ARE IN NAUTICAL MILES

NOTE-CONSULT THE CORPS OF ENGINEERS FOR CHANGES SUBSEQUENT TO THE ABOVE INFORMATION

PRODUCED BY COMPUTER ASSISTED METHODS

Figure 5

Figure 8

NO	LOCATION	TIDES: MEAN RANGE-FT	TIDES: DIFF (HRS) SAN FRANCISCO	DEPTH: APPROACH-FEET(REPORTED)	DEPTH: ALONGSIDE-FEET(REPORTED)	SERVICES: BERTHS-ELECTRICITY	SERVICES: RAMP-SURFACED-NATURAL	SERVICES: REPAIRS HULL-ELECTRONIC-MOTOR	SERVICES: MARINE RAILWAY-FEET	SERVICES: LIFT-FIXED-PORTABLE-TONS	SERVICES: BOAT RENTAL ROW-MOTOR-CHARTER	SERVICES: BOAT RENTAL HOUSE-SAIL	SERVICES: MEALS-LODGING	SERVICES: TOILETS-SHOWERS PUMPING STATION	SERVICES: WINTER STORAGE-WET-DRY	SUPPLIES: CHART SALES	SUPPLIES: WATER-ICE-BOTTLED GAS	SUPPLIES: GROCERIES-HARDWARE	SUPPLIES: BAIT-TACKLE	SUPPLIES: DIESEL OIL-PUMP-TRUCK	SUPPLIES: GASOLINE-PUMP-CAN
1	NEW HOPE LANDING	3 0	+7¼	15	10	BE	S				RM		ML	TSP	W		WIB	GH			P
2	DEAD HORSE ISLAND	2 7	+7¼	8	8	BE		HEM	70	F75	RMC		M	TS	W	C	WI	GH	BT		P
3	SNODGRASS SLOUGH	2 7	+7¼	10	5	BE						H								P	
4	ANDRUS ISLAND	4 0	+6¼	20	4								M	T			WI				P
5	SACREMENTO RIVER	2 3	+6¼	20	20			H M		F2				T	D		W				P
6	STEAMBOAT SLOUGH	2 3	+6½	10	12	E							M	T	W		WI	G	BT		P
7	STEAMBOAT SLOUGH	2 3	+6½	10	8	BE							M	TS	W		WI				P
8	MINER SLOUGH	2 3	+6½	8	5	BE	N						M	TS	W	C	WI		BT	P	P
10	COURTLAND	2 3	+6¾			B							M	T			WI	G	B		P
11	COURTLAND	2 3	+6¾	12	10	B			16	FI	RM		M	T			WI		BT		
14	CLARKSBURG	2 3	+7¼	12	12	B			20	F2											C
15	FREEPORT	2 3	+7½	20	15	BE		M	17		RM			T	W	C	WI	H	BT		P
16	FREEPORT	2 3	+7½	12	12	BE					RM		M	T			WI	GH	BT	P	P
17	SACRAMENTO	2 3	+7½	16	8												I		BT		
18	SACRAMENTO RIVER	2 3	+7½	18	15	B								T			WI		BT		
20	SACRAMENTO RIVER	2 3	+7¾	12	9	BE							M	T P			W		T		C
22	OAK HALL BEND	2 3	+8	20	20	BE							M	T	W		WIB	H	BT	P	P
23	RIVERSIDE	2 3	+8	8	20	BE	S				RM		M	T	W		WI		BT		P
24	CHICORY BEND	2 3	+8¼	10	10	BE	N							T					BT		P
26	SACRAMENTO	2 3	+8½	6	6	BE	S										WI				P
27	BRODERICK	2 3	+8½	13	5			H M	36					T	D						
27A	BRODERICK	2 3	+8½	8	8	BE							M	T			WI		T		P
27B	BRODERICK	2 3	+8½			BE		H M							WD		W				
29	SACRAMENTO RIVER	2 3	+8½	12	12	E		H M					M	T	WD	C	WI	H			
30	SACRAMENTO RIVER	2 3	+8½	18	8	BE							M	T			WI		BT		
31	SACRAMENTO RIVER	2 3	+8½	18	18	BE							M	T			WI				P

(+)DENOTES HOURS LATER (-)DENOTES HOURS EARLIER

THE LOCATIONS OF THE ABOVE PUBLIC MARINE FACILITIES ARE SHOWN ON THE CHART BY LARGE PURPLE NUMBERS

THE TABULATED 'APPROACH-FEET(REPORTED)' IS THE DEPTH AVAILABLE FROM THE NEAREST NATURAL OR DREDGED CHANNEL TO THE FACILITY

THE TABULATED 'PUMPING STATION' IS DEFINED AS FACILITIES AVAILABLE FOR PUMPING OUT BOAT HOLDING TANKS

THIS TABULATION WAS PRODUCED USING COMPUTER ASSISTED METHODS.

Figure 6

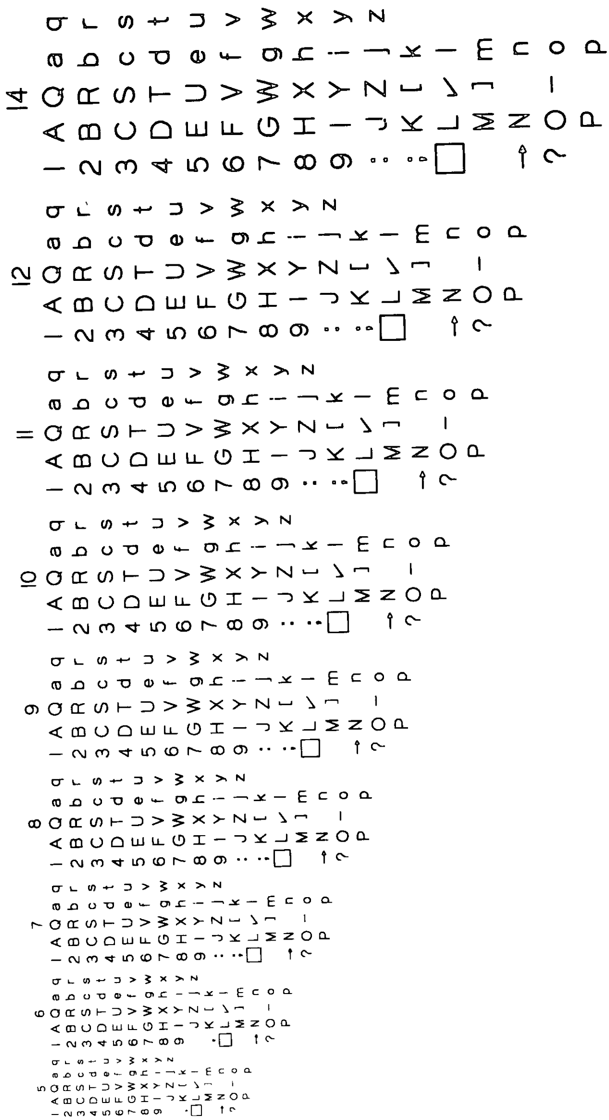

Figure 7

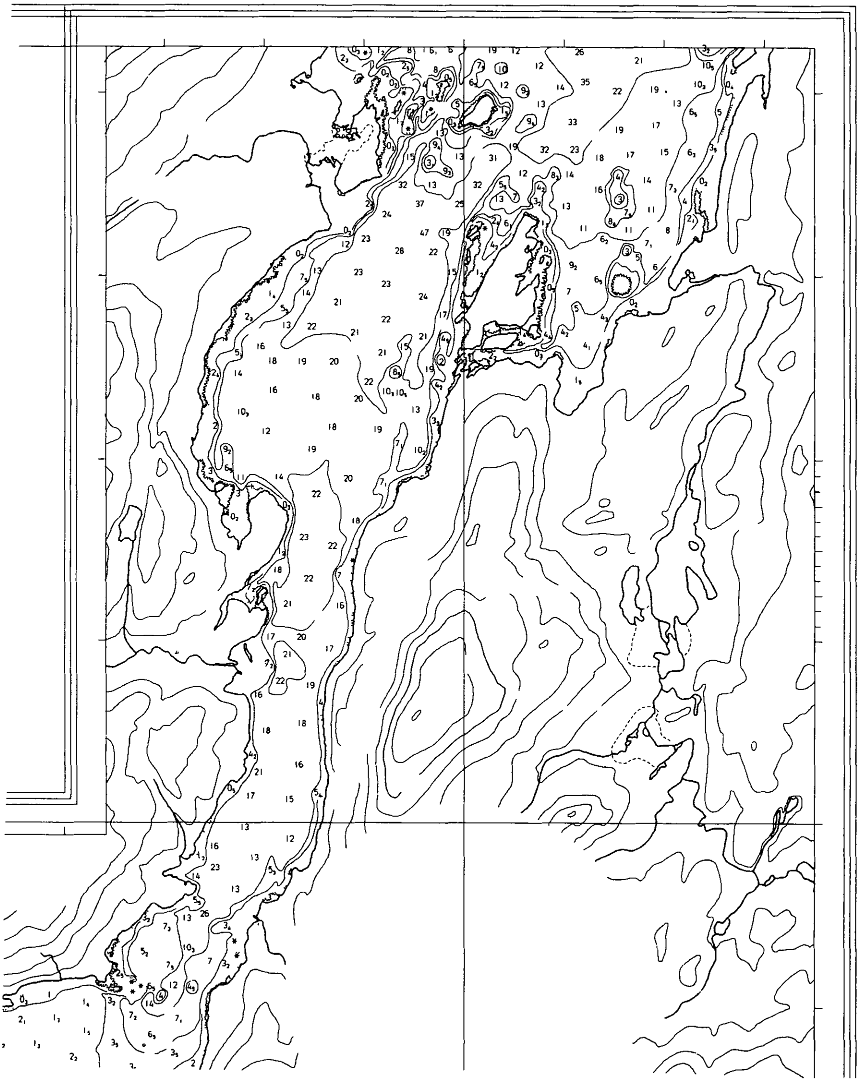

Figure 9

DR. BOYLE: We are going to ask Bob McGrath to come up. Bob McGrath is from DMA Hydrographic Center, and has had considerable experience with the different types of systems being developed.

MR. ROBERT MCGRATH: Thank you, Ray. Good morning. I think we should get into a little bit of background as to what the Hydrographic Center does. Mr. Bruce Optiz alluded to it briefly yesterday. We produced two types of products. One is digital products; typical uses would be radar simulators and collision avoidance systems. The second type of product is hard copy charts. These are navigational charts to support the fleet and worldwide maritime trade. These hard products are, as I said, the meat of our effort. We have been, for a period of time, using computer-assisted cartographic procedure. We have not gotten into raster technology yet, but we do have basic systems, the LIS in particular, where we capture data in digital form, classify the data -- that is, define whether it is a road, shoreline, coastline, or whatever -- create a data base and format charts for navigation and a number of other uses. I would like to address the use of the hard copy plotters in the production environment. I am not going to talk about the coming laser technology or the scanner operations that will improve production. But I will discuss some of the problems that were encountered in using the flatbed plotters. There are two plotters in use, the Xynetics and the Gerber.

The Xynetics is used primarily as a proofing plotter to check the accuracy of the information captured on the Lineal Input System. One of the problems is the ability to check the positioning accuracy of our data but not the classification accuracy. The Xynetics is not capable of generating line weight symbolization and charts produced full point and line symbolization is required. Therefore, it would be possible to have a city boundary in a correct position but classified incorrectly through an operator error when the data was captured, it would appear on the chart with incorrect symbolization (incorrect line weight.) An oil pipeline has a special symbolization that is used when display on a chart. It appears as a dashed line with a dot on the end of each dash. If it were incorrectly classified it might appear as a solid line in the proof plot. These are the things..........

These are the errors that could not be check on the Xynetics plotter. The Xynetics plotter is a good device for a quick positional check on the accuracy of the data, but it does not present a detailed enough picture to the operator. He cannot verify sufficient feature classification accuracy.

The effect is the operator would complete collecting the information he required and prepare for a color separation computer run on the Gerber. Color separation operations can require two or three hours to complete for one chart. On the Xynetics the same proof plot take ten or fifteen minutes. If the data is incorrectly classified, the Gerber run is wasted, and must be repeated. Our solution to the problem is to add a classifications information symbolization to the Xynetics plot program. One point that is worthwhile making here: When plotting a point feature on the Xynetics a (+) tick mark is used, just a tick mark to indicate that there is something there. No symbolization for a buoy or sounding. You would not get the depth. Incorrect feature classification would go undetected. Again, the solution is to add a more detailed symbolization package to be operated on the Xynetics.

Once the data collection is completed and the operator is satisfied, the data will be processed to achieve color separation and the specific formating required for the chart itself, generating four separate color plates for reproduction. The Gerber is the primary device now in use. It operates in three modes and is being expand to include a fourth. The three modes are: running with an ink pen, (seldom used), running with a scribe (also infrequently used), and the use of the photo head. The use of the photo head has several problems involved with it. The aperture wheel employed by the Gerber has only 24 apertures. This presents a rather limited symbolization capability if you have a wide range of symbolization to be presented. Since you are working with light sensitive film, the room where the film is being shot is in subdued lighting. It is inconvenient and difficult for the operator to change the aperture wheel and extend the range of his symbols. That is a problem. It is a limiting factor. It also increases the production costs as you go through your daily operation. When tracing a line on the Gerber, it is necessary to slow down physical movement of the aperture selecting to obtain the desired line weight. With each movement from the beginning of one line segment to the end of another the Gerber physically stop and mechanically snap the shutter even though there may be a continuation of the line. The problem, again, is time. You are slowing down for the mechanical operation of the aperture. It may not sound like much, but if you are dealing with highly convoluted lines that have many thousands of short segments, this increases the run time considerably. The problem here again is time, operator time, hardware time and production time.

The fourth method that I alluded to is expansion of the Gerber with a CRT print head. We have high hopes for the CRT print head. We have not taken it in our shop yet, but we do expect to have it very shortly. The CRT print head is a device that will mount on top of the Gerber in place of the photo head right on the current gantry, so there is a minimum of change to the equipment itself. The CRT print head also has a separate PDP 11/45 used to drive the print head. There are no photo apertures, as the name implies. The procedure is to sweep an electronic beam on the CRT, and it in turn imprints on the film. The advantage here is that associated with the 11/45 there is a large disk area where all symbols will be available at any one time. When a character is to be flashed, the machine will read the character code, go out to disk, read in the symbol and sweep the feature, the character or the symbol. Another and crucial point here that is going to save even more time: The CRT print head has an area of approximately three inches square that is a usable surface. The plan obviously is to sort all of the data that will appear on the chart in production, reduce the data up into a series of "pages" approximately three inches square, and move the CRT print head from page to page, sweeping all of the information in that three-inch square at one point in time, doing it at the speed of a CRT capability.

With the other system, the photo head, if you wanted to flash a sounding of 29 fathoms, the print head would move to the position of the first digit, the two, select the aperture, take time for it to spin around, flash the two, move to the position for the second digit, the nine, select the aperture, spin again, and then flash. All very time consuming problems. The gantry does not move that fast, either. It moves rather slowly. Again, all these things add up to limited production and increases in cost. The advantage of the CRT print head is realized when we reduce the data to be plotted into a series of "pages" and read the data back a page at a time; process each page, read each of the symbols, whether they are a buoy symbol or a sounding or a segment of a line -- the gerber will print all the information from one position for each page. There is no continuous back and forth motion of the gantry for individual symbols across the film itself.

We estimate that we will be able to process a chart that is 40 by 60 inches in approximately 15 minutes. That is a marked improvement. That is a savings of hours over what it is required right now. There is another advantage that has not been mentioned. If your font library resides on disk, you have a much greater repertoire of characters and fonts that can be reference at any period of time. Even though you are limited by disk storage, there is the capability to store a series of fonts libraries off-line on tape and read in the font library you are specifically interested in when required. It appears to HC that the CRT print head will, in today's non-raster type environment greatly increase our production capacity. I hope I have pointed out some problems that you are either getting into or are working with already and will be able to commiserate with and say, "Yes, I had that problem, too."

Thank you.

(Applause.)

DR. BOYLE: Thank you very much, Bob. I think that the CRT head has considerable application, particularly for upgrading the work of those who have large slow flatbed plotters which are very good for symbology and for names. I am not quite so convinced for linear work whether this paging process works, having lived through the abortive attempts by the USGS in the late 1960's--some of you might remember the very small error that can occur because the non-linerity in the CRT pages is immediately obvious from across the room. Pages have to be very, very precise indeed and I am not certain that this can be maintained using a CRT print head. Certainly, for a quick look, but for final precise drafting, I want it to be proved to me yet that it is good.

Now I am going to ask Richard Kidwell to come to the stand. Richard Kidwell is a user. He is in the Publications Division, Office of Research and Technical Coordination, at U.S. Geological Survey in Reston, Va. We have had several good discussions, and he has given me very large amounts of things to think about on the use of the scan plotting to handle a large amount of symbology, the areas of symbology, and so on, used particularly in the geological maps. I was very impressed with his thinking on this, and I asked him to come along to be representative of a user having a need of this sort of thing. So, Richard, if you would take the stand, please.

MR. RICHARD KIDWELL: Good Morning. Computer-assisted hardware copy display devices currently being evaluated in the Office of R&TC are the cathode ray tube plotter, the rotating mirror laser beam plotter, and raster drum plotters. The applications that we have are for film separations for LANDSAT data derivative maps, printed lithographic map sheets, geophysical maps, area fill for thematic maps, and automating the map lettering and symbol placement.

The principle hardware used for these applications has been Optronic's scanner/plotter. This device has an 8-by 10-inch drum. Routinely, it can scan or plot an image on a sheet of film in about 5 minutes at two-thousandths of an inch raster. An interesting application is a vegetation map for Nigeria, which is seeking a site for a new capital. Each of the separations for this vegetation map was plotted out as an open window from LANDSAT tapes by Pat Chavez at the USGS Flagstaff Office. There are six classifications. We had six plots of this sort (figure 1), all at the 8- by 10-inch size. To complete the plotting, band 7, which is in the near-infrared spectrum showing continuous-tone imagery of the ground, was produced with a minimum density of 0.40 and maximum density of 1.40 (figure 2). Band 7 image was enlarged 10 times and halftone screened for printing in each of the six land classifications areas. The open-window separations, also enlarged 10 times, served as masks for the band 7 LANDSAT imagery. In the final printing, each of the six classified areas was printed in individual ink colors with the band 7 imagery printing in each of these areas. Thus, you have a different type of map than normally presented, where the classified areas are printed as color tints over an image base. In this application, the image base itself printed in each of the classified areas, giving more detail in this 40- by 60-inch map at a scale of 1:100,000.

The next example is a map of the greater Washington, D.C., area with separations produced on a Mead Technology Laboratories rotating mirror laser plotter. The dots are generated as a fixed two-thousandths spot. The raster spacing on centers is one and three-quarter thousandths, which results in overlaping dots in a matrix to produce each pixel in the proper gray value (figure 3).

This is a view of the device itself, the rotating mirror is at the lower left corner. The copy that is to be scanned or printed is in the trough with copy size limited at this time to 14- by 24-inches. It takes about 2 1/2 minutes to print a separation. The map published for these separations is 24 inches square; so two sets of scans were made and joined photographically for the final printing. There was quite a bit of mosaiking to put the final copy in perfect register owing to computer processing of the LANDSAT data and the base-map linework. The device itself appears to have worked well. Separations were produced for the black, cyan, yellow, and magenta printers. The tints for each of these processed colors were derived from the pixel dots in the matrix. In the case of the Washington Urban Area map, Mead used an 8- by 10-inch matrix. This is one of the actual separations (figure 4). There are three separations sandwiched together on this slide. The cyan and magenta, and the black. You can get an idea of how they go together. Each one of these would be produced one at a time on the plotting device. The small circles that you see drawn around some of these pixels were used to register the copy perfectly. As I mentioned, there had to be some mosaiking to make a perfect fit. There were no register marks generated in the production of these separations, which is another item that I think is important to have. Register marks should be electronically generated with the copy. A pin-register system on these devices would be an additional improvement in the assembly of the separations.

This is a view of the Information International CRT device used at the Bureau of Census. The images are generated on the cathode-ray tube and photographed by camera within the device on 35-millimeter film. The problem that we have had with this type of device is that the gray values are not too well controlled, there is some loss in definition, and a registration problem exists. Here is a 22-times enlargement of the separations to publication size. The data, which are the black masses you see on the copy, have rounded edges but would normally be rectangular shaped (figure 5). Some of the areas were so small that we could not screen them with a conventional halftone screen so we used a random dot screen, which looks like so many worms, that captured most of the fine detail. The separations couldn't be registered perfectly; so the process has not been used in production. One thing that we are doing, though, as a result of this evaluation, is to have designed a very fine random-dot screen to use on LANDSAT data, where the imagery is very small and you do want to capture data now lost with conventional halftone-dot screening. We expect delivery of this new screen later this year.

In the reprinting of maps from lithographic edition prints, we are currently using a graphic-arts HCM color scanner in our USGS Branch of Printing. Size limitations are 19- by 23-inches. It produces one separation at a time in about 30 minutes at two-thousands of an inch raster. This slide shows the quality of a contour separation made from a lithographic sheet that has no green woodland overprint (figure 6). When we use a green overprint, the contours essentially cannot be separated as they do not reproduce well. So it has a limited use in topographic map feature separations; however, adequate process-color separations can be made for reprinting. On the other hand, for reprinting geologic maps, we make yellow, cyan, and magenta process-color separations and reproduce these quite faithfully. However, when we have to scan the map in two or more parts, which is reasonably frequent because of our large map sheets, the result is marginally acceptable. The device is a continuous-tone imaging scanner that produces halftone screen copy by exposing through a screen in contact with the film. There is difficulty in making each of the separations a perfect match along the join edges from both equipment and film processing limitations. The continuous-tone generation devices have this limitation in contrast to hard-dot generating device of the laser type.

For geologic-map area-fill separations, Al Williamson, of the Corps of Engineers in Vicksburg, Mississippi, made a set of separations at two-thousandths raster for us on an Optronic's scanner. The line copy was scribed at roughly 25- by 30-inch size. It was reduced in size to 5 by 6 inches, and area fills were produced for each one of the mapped units. These separations were then enlarged five times for publication. In the enlargement to five times, we had ten-thousandths-inch pixels and occasionally double-size pixels to twenty-thousandths line width, whereas the original copy was scribed at five-thousandths (figure 7). However, by overlaying the scribe copy, and screening each of the open windows with a 120-line screen, it smoothed out the ten-thousandths pixel steps so that you really don't notice the stepping too much along the perimeter of the area fill. We plan to go into production with one or more of these jobs with areafill separations made by Corps of Engineers and line separations by USGS. The cost is approximately $1,500 for a set of 18 separations on 30- by 40-inch film, which is comparable to or a little less expensive than what it would cost us to produce the separations by the conventional peel-coat method.

Area measuremnt is also available by scanning and impractical to obtain by manual methods.

A SCI-TEX North Amercian Corporation System evaluation on reproducing feature separations from a topographic lithographic sheet with green woodland was sucessful. The SCI-TEX system includes a 36-inch-square scanning drum, color video terminal, and a 42- by 75-inch laser drum plotter. I believe this will be discussed later by the SCI-TEX people; so I will skip over this example. The demonstration on this equipment indicates that our maps can be processed on this equipment because of its color CRT terminal, large size, and laser-dot capability.

An experimental geophysical map was produced by Richard Godson, USGS Denver Office. The geophysical data are initially collected from aerial sensors in digital form. Film separations were made on an Optronic's drum plotter by dividing the digital data into 17 groups for gray level plots using the equipment's 0 to 255 gray-level steps. The yellow ranged from no yellow at 0 to solid yellow at the mid-point or 128th step and back down to no yellow at step 255. The cyan separation ranged from solid color at 0 to no color at the mid-point or 128th step. This technique places solid cyan at the low sensor intensity and yellow at the middle of the intensity range while at the quarter point an equal amount of yellow and cyan mix to make green. At the high end of the gray scale, magenta ranged from none at 128th step to a solid at 255th step. This permitted magenta to print at the high end of the scale and a equal amount of yellow and magenta to mix at the three-quarter point for orange (figure 8). These separations were enlarged to publications scale and halftone screened but not printed as that was not part of this test. A proposed West Virginia State map is planned with a modification of this procedure. The principal thing learned from this test was that the continuous-tone separations must b prepared to accommodate the lithographic printing density range of 1.0 for the film separations if lithographic printing is planned. The low density point should be 0.40 and the high density 1.40 for predicatabl color-printing results.

The most recent letter and symbol-placement application involves Optronic's 17- by 22-inch Pagitron raster drum scanner/plotter. The estimate is about 10 hours of equipment time to handle 600 symbol and text placements on a 30- by 40-inch geologic test map process in four parts 17- by 22-inches each. Rotation of symbols and lettering is a software problem that must be resolved for success.

In conclusion, hardware devices and software exist now to produce cartographic separations for multicolor map publications. Open window for fill areas, production of separations from printed lithographic maps for republishing and LANDSAT derivative map applications for complex maps are cost effective, if properly selected. Geophysical maps and symbol placement are likely effective applications. Linework and lettering applications need more study. Continuous-tone film separations should have a density range of 1.0, from a low of 0.40 to a high of 1.40, to fit the lithographic-printing limitations. Plotting at two-thousandths of an inch appears adequate for linework while open windows may be plotted or camera enlarged to ten-thousandths of ai inch pixel size provided the window areas will print with screen tints to smooth the pixel steps along the color boundary and thereby improve the register appearance. A pin-register system is needed on the devic to assist in the assembly of the separations for final printing. Thank you for your attention.

ILLUSTRATIONS

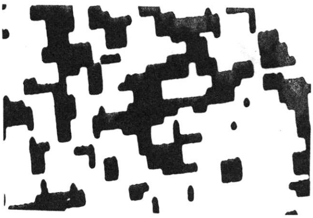

Figure 1.--LANDSAT open window negative.

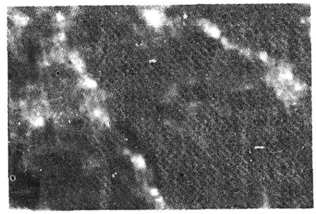

Figure 2.--Halftone image band 7.

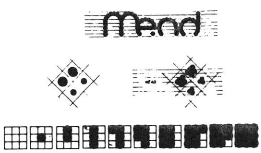

Figure 3.--Mead's gray value matrix.

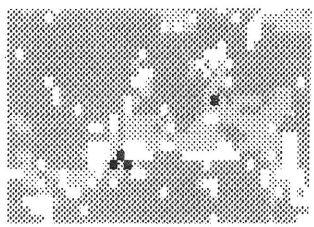

Figure 4.--Mead's color separation.

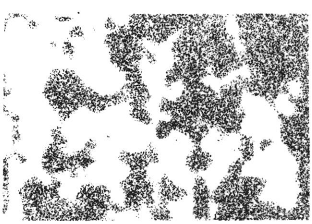

Figure 5.--LANDSAT CRT separation random dot screened.

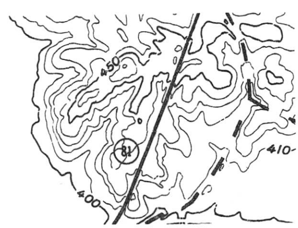

Figure 6.--Contour separation from color lithographed edition. Red roads would not separate from brown.

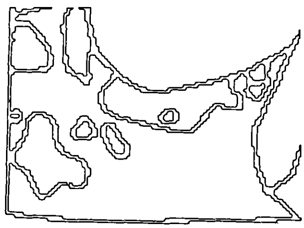

Figure 7.--Stepping of pixels in plotting of scanned line work.

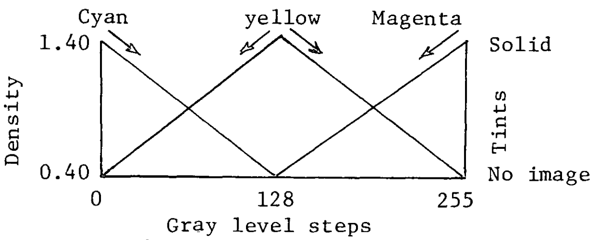

Figure 8.--Color separation schema for geophysic test map.

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Information International, Culver City, California

Mead Technology Laboratories, Dayton, Ohio

Optronics International, Inc., Chelmsford, Massachusetts

Sci-Tex North American Corporation, New York, New York

Persons

Chavez, Pat, Jr., Computer Center Division, U.S. Geological Survey, Flagstaff, Arizona

Godson, Richard, Geologist, U.S. Geological Survey, Denver, Colorado

Williamson, Albert N., research physicist, U.S. Army Engineer Waterway Experiment Station, Vicksburg, Mississippi

Publications

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Overstreet, William C. and others, U.S. Geological Survey, "Provisional Map Showing Land Use Based on Interpretations of Vegetation Federal Capital Territory, Republic of Nigeria", 1977.

DR. BOYLE: Thank you very much. (Applause). We are now going to ask Mr. Gray to come to the microphone, from the DMA Hydrographic Center. He is going to talk about going directly to the printing plate. It is necessary for us to go to, as you have seen in almost all of these discussions so far, to make the photosensitive sheets and then go to a plate for printing -- cannot we directly make the photoprinting plate? He is, I think, mainly going to concentrate on that aspect of the work. So, I will introduce Mr. Gray of DMAHC.

MR. CHARLES R. GRAY: Thank you, Ray. The emphasis until now has been on the automation of the cartographic procedures that apply to a particular product. I want to discuss the graphic arts procedures that are going to be the tail end of the cartographic procedures and how they get from procedures to the hard copy chart or map, which is the Defense Mapping Agency's primary product. The paper chart and map is here today and is going to be here for many years to come. We do not look for its immediate demise with all these digits and widgets floating around. We are just going to change the procedures as to how we get to this final product called paper. This is a sample of a product that the Defense Mapping Agency Hydro Center puts out, not too dissimilar from either of our two sister centers, Topographic or Aerospace Center. Just the data on it is different. It is still paper. We have to get to the press plate. We have to print this product.

In 1972, when the Defense Mapping Agency was formed, an active R&D program was established to develop an automated means of producing maps and charts and all of their related products. As a result of this R&D program and later programs designed to achieve automation, a subtask was established to develop a digital to press plate capability. In 1975, the laser plate maker evolved from this subtask. Just last year, in September of 1977, a developmental contract was let by the Engineering Topographic Labs -- Fort Belvoir -- to the EOCOM Corporation in Irvine, California, to develop this equipment to meet chart specifications submitted by the Defense Mapping Agency Hydrographic Center. This equipment is scheduled for delivery in December of this year. It will provide the Defense Mapping Agency a read/write scanning capability. It will provide the capability to use existing chart and map files, of which all three centers, including the new Hydro-Topo Center, have an immense storage file of reproduction negatives and positives, which are currently their primary source for producing their products. We do expect to use these for many years. We do not expect to see them hauled away in the trash truck just because magnetic tapes are here. Tapes have not proven totally reliable yet.

At a later time, digital equipment will utilize the raster data which is in final edit format, and will command the Platemaker to expose a film for storage and proofing and a diazo plate to be used on the large format, 43 by 60 inch, three color offset presses that we use at the Hydro Center. This capability will support the Foreign Chart Program or the Foreign Chart Subsystem.

The Foreign Chart Subsystem will provide the Defense Mapping Agency, Hydrographic Center, with the capability to fully utilize all the chart material received in its treaty agreements with foreign countries for the interchange of information. The Foreign Chart Subsystem's three components -- the color raster scanner, which is currently being built by Hamilton Standards, a raster editing device, a raster finishing plotter, and/or the laser plate maker -- will increase production and allow the Defense Mapping Agency to meet its future requirements without any additional manpower costs. More and more real time commitments and requests are coming in to DMA for its products, and it just stands to reason that it is easier to manipulate data in digital format on a time basis than it is in analog format. It presently takes about three months or longer to cycle a chart through the Hydrographic Center from the time that the request comes in until the time the paper product goes out the front door. Time is manpower and manpower is expensive -- so comes the digital domain.

What prompted the digital plate maker? For about four years a number of commercial companies have been involved in the development of this technology, primarily around the newspaper and printing publications requirements, 18 by 24 inch format. This would do for our publications, but that is all. We in the Defense Mapping Agency use plates as large as 47 and a quarter by 60 inches. We require high resolution, just a little bit better than you read in the newspaper by scanning with a 25 micron spot size. We need multi-burn plate composition capability, and we want to merge digital and graphic data using automated and conventional methods to expose our diazo plates. As I said before, we have a very large chart/map file of information that we do not plan to dispose of, so we do want to have both capabilities, the digital and conventional technology-both-to make plates for the time being.

The future products that we at DMA will print with automation should not require any increase in manpower. We propose in the facsimile mode to use the chart original. This is made from the hand assembled manuscript compiled in the carto area, and then go directly to a press plate and a new negative. The laser plate maker is not going to just make plates. It is also going to produce a film negative simultaneously. We expect to be more flexible in the handling of different types of graphic input than we are at the present time. Everything now is manpower intensive, and we expect to reduce a good portion of this. We will store data in lineal format, and convert to raster for scanning on the plate maker and film plotter.

We expect to realize pre-press savings, in manpower costs, and some material costs, mostly in the stripping, and negative engraving areas. We expect to supply our users, the Naval and Maritime Fleet with a quicker turnaround time as their needs are identified for the DMAHC Charts. The laser plate maker will have new demands placed on it in the future. As new and better lasers become available, we will be looking at these. Lower powered lasers, visible lasers, to expose new plate emulsions in the visible range. This is the electrostatic, electrophotographic materials that are emerging. I have actively been going around the country in the last twelve months taking a look to see what is out there. There are new materials available and they will be available in the future in the sizes we at DMA need. Right now, again, they are geared toward the newspaper and publishing industry. We need two and a half times that area from 18 by 24 to 47 by 60 inches.

We expect to use low power helium neon or YAG lasers rather than the big, high power argon lasers used in this device when the spectral output and the photosensitivity of the new plates match up. We expect to use these electrostatic plates which will provide higher resolutions and speed on the press rather than the current plates that we use, which are brush grained aluminum diazo plates, if they are cost effective. In the future the DMA can expect to have master and slave units for transmission of graphics between centers or to meet other field requirements. This potential does exist, and in real time as is demonstrated by some newspapers. We do expect electronic screen generation as a future requirement in the development of the laser plate maker. The Defense Mapping Agency currently uses 120 line standard screens. We will be looking at the capability to generate this type of screen electronically as the plate is being recorded rather than manually the way we do it now.

The future may hold direct to press plate color separation. We do not have a large interest in this, since our product does not involve the type of color separation that probably most of you are familiar with. But we want to monitor this development. Some of these technologies are here today, and as they are refined or developed, the Defense Mapping Agency will monitor them closely for potential use, providing they prove cost effective over the current state of the art. These developments must prove to be economically realistic.

In our discussions with personnel from EOCOM Corporation, the technical people propose the three module construction which can operate in a same location or in a different location tied together by coaxial cable. As you look at the LPM, the first unit on the left is the read unit. This is the one that will accept the original or the paste-up and read it, using a four milliwatt helium neon laser. The one in the middle, or the one on the end, depending upon which way it is configured, will be the film writer. This will use a ten milliwatt air-cooled argon laser, and it will expose conventional ortho and reproduction type materials up to 60-inch format at four, seven and ten mil thicknesses. Let us say the one on the far end, then, will be the one that does the job. This is a two and a half watt argon laser, and is the plate exposing laser. It is a water cooled laser, and it will be a closed loop type of water cooling so we don't waste all the water that flows down the Potomac.

The plates that DMA will use are the plates we currently have on hand right now. This is the RPB type plate, 47 and a quarter by 60 inch, which is a brush grained plate, diazo roll-on emulsion. The Topographic Center, where we anticipate moving within the next five or six months, uses a Western Litho negative plate. That plate also is a candidate for this laser, and it does fall within the spectral range of the laser. The peak spectral range of these plates is 372 nanometers. The spectral range of the exposing laser is 363.8 nanometers. So, most of the energy and efficiency will be in the right range. The configuration is an internal drum scanner. It is three units, as you can see up here. It will accept negatives or positives as input. It will output a film or a plate or film and a plate. You can control either/or; you do not always have to generate a film. However, in the case of the DMA chart/map product, the film is the data base, it goes into file at the present time for storage. As we update our product, we store the newest version of that update. That is why we must still have the film. So, until such time as the DMA digital data is totally reliable, and this is coming, we still must rely on our film base technology to back up our products.

There are no particular special humidity or temperate conditions for this laser plate maker, other than just a clean operating area. We expect to put it in a room, in the plate maker area, near the press room. The temperate range it will operate effectively in is 60 to 80 degrees, relative humidity from 20 to 80 percent. The only additional feature that has to be established in the complex where this is going to be is a little darkroom where the film exposing module will be put, along with its own dedicated processor for the repro material.

From a graphic arts standpoint, these are the requirements or specifications that were established by the Hydrographic Center for this unit to meet. It must accept a 49 by 62 inch paste-up, or "flat" for scanning. It must accept a 47 and a quarter by 60 inch grained aluminum plate, and on this the maximum image size, can be up to 41 by 59 inches. It must record a 120 line screen, 4 percent to 91 percent tint, 5 to 95 percent half-tone. Provide a plus or minus two mil line weight or image resolution compared to specifications now available on standard charts and maps. Accept positive or negative copy. Provide registration of color separated images to plus or minus two mils. Provide even density across the plate, whether it is a solid, line or half tone. We do not feel that we have to sacrifice any image quality whatsoever just because we are going to automation. We have a good product now, we want to keep it that way or improve it. It must produce a press-ready single-plate exposure every 15 minutes or less at maximum image size, 41 by 59 inches, two or more exposures per plate. It must provide multiple exposure capability to plate for single color image composition. It must provide negative for proof or storage capability. It must provide a clean plate non-image area, dirt-, scratch-, and/or scum-free. It must operate in a white light environment. Laser plates supplied or recommended must operate using standard and/or alcohol dampening systems. It shall except an in-house pin registration system.

Now, these specs are just a little bit more than the newspapers require more along the line of commercial printing, and this is why I say, we are not going to back off on any image quality just because we are going automation. Thank you. (Applause.)

DISCUSSION

HARD COPY DISPLAY

DR. BOYLE: Thank you very much. The floor is yours for questions for the next 15 minutes. We have overrun our time a little, but I think they have been very interesting presentations, and you now know the people you can approach when you have to make some of your own decisions.

MR. RAY DILLAHUNTY: Ray Dillahunty. I am with Geoscience, Houston, Texas. I was just curious as to what the resolution is for the CRT head for the flatbed plotter you were using or intend using. I did not hear any comments as to resolution.

MR. McGRATH: The resolution is supposed to be plus or minus one mil. One thing I did not mention about the CRT print head: The characters are going to be presented in a raster form. The significance of this is that when you rotate a character, you rotate the entire raster. With the old techniques, when you rotated the character the character would tend to separate a little bit. By presenting the thing in a raster form it preserves its contour and the relative positioning of all the points. You get a better picture with the individual character.

DR. BOYLE: If there are no more questions, SCI-TEX offered to run their film. They have a rather attractive film of some of their manipulations. Thank you.