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U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

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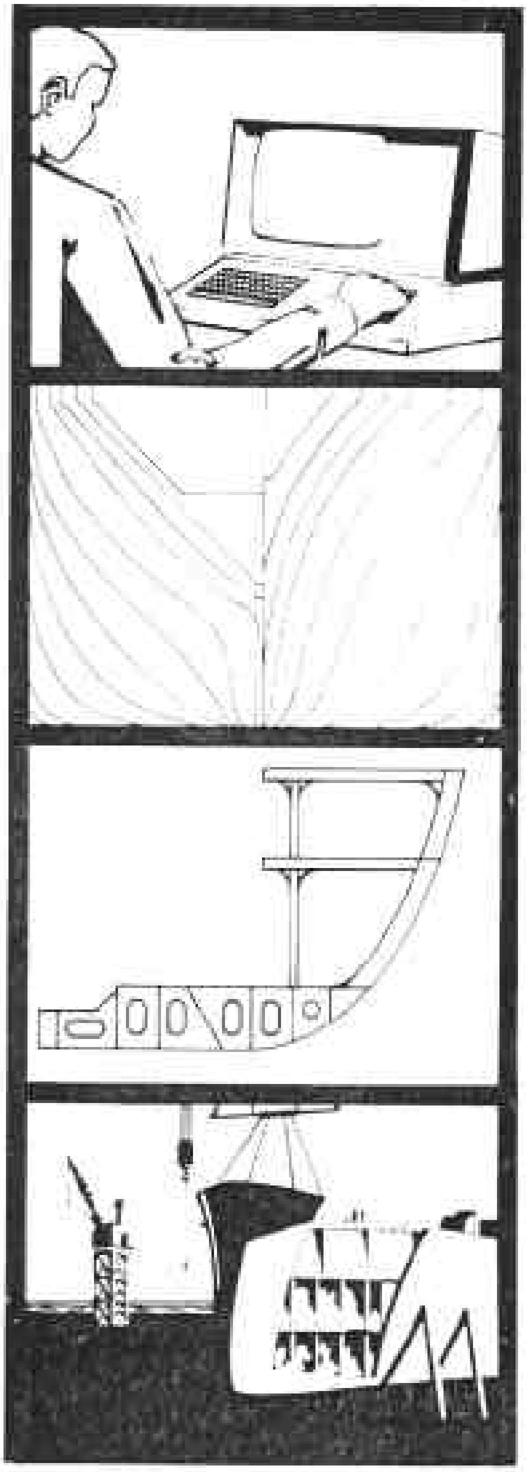

R ESEARCH
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AND
P RODUCTIVITY
IN
S HIPBUILDING

Proceedings of the REAPS Technical Symposium

September 11-13, 1979

San Diego, California

SEMI-AUTOMATIC PIPE PRODUCTION IN A SMALL SHIPYARD

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Mr. Waring is Vice-President of Port port weller Dry Docks, where he is currently responsible for shipyard production, productivity, planning, cost control, and computer systems. Mr. Waring has received the Higher National Certificate in Naval Architecture from the United Kingdom. His past positions include Manager of Planning and Cost Control, and General Superintendent.

This paper has been written with the small shipyard in mind, and to comment on its approach to large new piping systems incorporating the latest developments in production equipment and computer aids. Small yards face a common problem when confronted with large systems together with their associated software packages and extensive hardware requirements for both computers and production equipment. The obvious common problem is the volume of throughput and the need to generate sufficient savings to justify the level of investment required. Even if theoretical savings were sufficient, it is unlikely that a small yard would have sufficient resources to successfully incorporate all the changes in ***one*** step.

In recent years a number of small yards have introduced large computer systems for N.C. steelwork (eg. Autokon System) by taking a step by step approach to its installation, and it is appropriate that their attention should now turn to the next largest labour intensive process in ship construction - that of pipework.

Recent changes in pipework processing range from the fully automatic integrated systems, through various levels of semi-automatic systems with computer aided design or computer aided construction.

A shipyard has a number of choices it can make regarding its pipework: -

a) A fully automatic system supported by comprehensive computer programs

b) A semi-automatic system supported by computer programs

c) A computer aided piping design system

d) A computer aided piping construction system

Large systems that incorporate fully automatic production equipment on the shop floor supported by computer programs for pipe design and pipe production data, offer the largest potential savings, but are necessarily expensive and beyond the budget of a small shipyard. These large systems such as Mitsui's Maps System, Hitachi's Hicas System or Germany's Oxytechnic System do, however, have component systems that could be used as a basis for a small yard semi-automatic application with a minimum of cost and a rate of return that would justify the investment.

It should be noted here that reference made to "semi-automatic" in this paper is not intended to indicate a processing system that is half automated, but rather to indicate that some of the equipment involved has some automated features that can be supported by computer aided design or computer aided construction programs.

When faced with the variety of choices, the dilemma we faced, as a small shipyard, was - on which piping system would we concentrate our limited resources? Since the ratio of production manhours to drawing office hours for piping systems approaches 5:l it was decided that the first place to invest money was on the pipeshop floor. The semi-automatic equipment purchased in Port Weller included the following: -

l - pipebender, 2 X D bends for 21/2" - 8" pipes
l - pipebender, 2 X D bends for 1/4" - 2" pipes
1 - pipe profiling machine with analog control for pipes up to 40" dia.

We-are currently investigating: -

1 - pipe flanging machine for use with loose backing rings on pipes up to 8" dia.

By installing this equipment, with or without supporting computer programs, some basic costs of steel pipe fabrication can be eliminated. For example, Fig. 1 shows a comparison of 2 sister ships recently built in Port Weller.

Fittings Purchased *	Sister Ships	
	Ship No. 1	Ship No. 2
	No. of Fittings	No. of Fittings
1. Standard weight, 90° and 45°, LR & SR Butt weld elbows:		
size l0" to 16" inclusive ---- -	88	11
size 8" and under---------.	173	0
2. Standard weight, straight & reducing tee's size. 10" X 10" X 10" & under,--	18	1
Total No. of fittings	279	12
Total value of fittings	$ 14,271.	$ 1495.
* Ship No. 1 constructed without bending & profiling equipment		
Ship No. 2 constructed with bending & profiling equipment		

Fig. 1 Fittings required for Bilge & Ballast System I.M.S. for 30,000 Ton Bulk Carrier

The first ship was constructed before the purchase of bending and profiling equipment, the second ship was constructed using the equipment. The elbow and tee fittings required for the manual construction of the Bilge and Ballast System I.M.S. are listed, and are compared with the fittings required for the semi-automatic fabrication. As shown - 95% of the fittings were eliminated in this system.

This type of saving is applicable to other systems, and 5 major systems are shown in Fig. 2. The total cost of. fittings eliminated on a vessel of this size approaches $40,000. Spin-off savings are encountered in reduced purchasing and storing requirements.

System	Sister Ships	
	Ship No. 1 Cost of fittings	Ship No. 2 Cost of fittings
Bilge,Ballast I.M.S.	$ 14,271	$ 1;495
Diesel Exhausts	6,257	
R.W. Circulating	5,546	45
Lub Oil System	3,035	175
Fuel Oil System	2,809	244

Fig. 2 - Reduction in use of elbows & tee's for major systems of 30,000 Ton Bulk Carrier.

The material savings are quite large in themselves, but take on more significance when one considers that they do not need to be welded into the system. Take, for example, a typical day's production on a bending machine with 8" dia. pipe. If 2 hours are allowed for a tool change, a bender operator could, on average, produce 24 machine bends in the remaining 6 hours. The approximate cost of these 24 bends would be as follows: -

16 hrs labour @ $8./hr =	$128.	(machine,is operated by 2 men)
pipe material in bends =	384.	
TOTAL	$512.	

The equivalent cost using elbows would **be: -**

24 x 8" dia. elbows =	$ 864.	
welder labour costs =	475.	(manual welding)
TOTAL	$1339.	

Incidental costs have been left out of both the above calculations. The ratio of costs - elbows:pipebender is approximately 2.62:1.

A similar analysis of 5" pipe gives the following results. Once again 2 hours are allowed for a tool change '(worst case 8" to 5" dies). In the remaining 6 hours an operator could, on average, perform 36 bends.

16 hrs labour @ $8./hr =	$128.
pipe material in bends =	225.
TOTAL	$353.

The equivalent cost using elbows would be: -

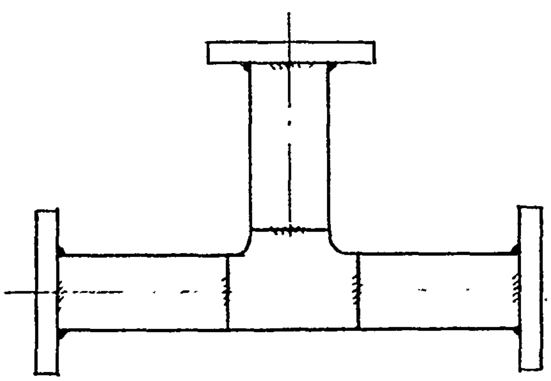
24 X 5" dia. elbows =	$ 697.
welder labour costs =	447.
TOTAL	$1144.

Once again, incidental costs have been left out of both calculations and the ratio of costs elbows:pipebender is approximately 3.24:1.

These ratios increase as the pipe gets smaller, especially 2" dia. and below, as the operation of a small bending machine becomes a 1 man operation. Further savings are generated when one considers that bending machines can produce any angle of bend between 0° and 180°, whereas trimming of the elbow is required when using fittings if angle of elbow is not the standard 45" or 90°. In many ship installations with tight engine rooms, use of 45° and 90° elbows, without trimming, it not always practical and a great deal of time is wasted in hand trimming elbows.

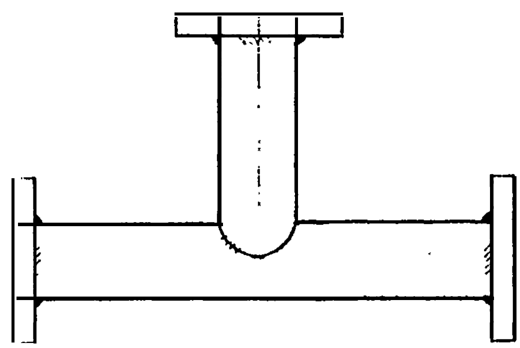
The use of profile burning machines to eliminate T's, Y's and large elbows (i.e. elbows> 8" dia.) also generates significant savings. One example will be enough to indicate the range of savings. Assume that the 5" X 5" X 5", 90° "T" fitting as shown in Fig. 3 is to be replaced by a profile burnt "T" as shown in Fig. 4. A purchased 5" X 5" X 5" "T" piece currently costs about $55. and has 3 welds and 3 edge preparations that would add another $30. labour charges to the joint for a total of $85. The profile burnt joint shown in Fig. 4 has 1 end preparation, 1 hole, and 1 weld. It takes about l/2 hour to set up the burning machine for a joint of this type, and about l/4 hour burning time. Manual welding would take a further 3/4 hour for a total labour cost of $11.50. The pipe material in the joint costs $6.25 for a total of $17.75. The ratio of costs "T" fitting: profile cut is approximately 4.78:1. Once again incidental costs have been left out of both calculations.

The "T" piece shown in Fig. 3 is a standard 90°, however optimum conditions for design are not necessarily 90°. The profile burning machine can cut holes and saddles for any angle and also for any combination of pipe sizes.



<u>Joint - using "T" fitting</u>

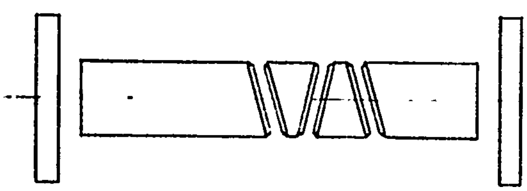
Fig. 3



<u>Profile burnt joint</u>

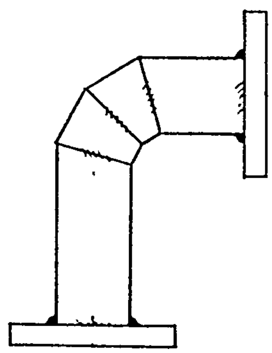
Fig..4

For larger dia. pipes the profile burning machine can also reduce requirements for large elbows. Fig. 5 shows the component parts cut from a straight piece of 16" dia. pipe. Fig. 6 shows the assembled joint. In this case, set-up time on profile burning machine would be 1/2 hour, there are 6 cuts which would take another 1/2 hour for a total machine operator time of 1 hour or $8.00. The cost of pipe material in the joint would be $38.00. There would be 3 welds in this joint which would cost $57.00 for manual welding. Set-up time for these 3 welds would be a further $12.00 for a total joint cost of $115.00.



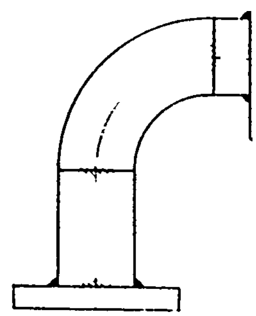
Component parts

Fig. 5



Assembled joint

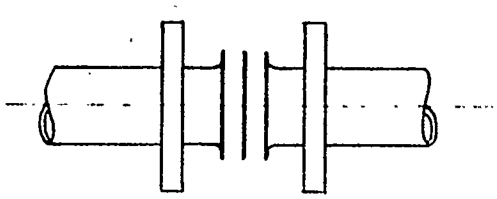
Fig. 6



Joint using elbow fitting

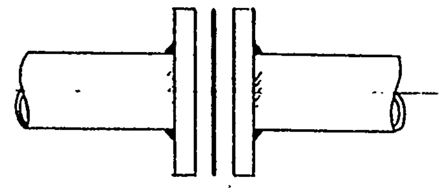
Fig. 7

An elbow fitting as shown in fig. 7 would cost about $200. to buy, $8.00 to set up, $38.00 to weld, $8.00 for 2 edge preparations, for a total joint cost of $275.00. The ratio of costs, elbow:prcfile-cut would be approximately 2.39:1. Once again incidental costs have been left out of both calculations.



Joint using loose backing rings

Fig. 8



Welded flanges

Fig. 9

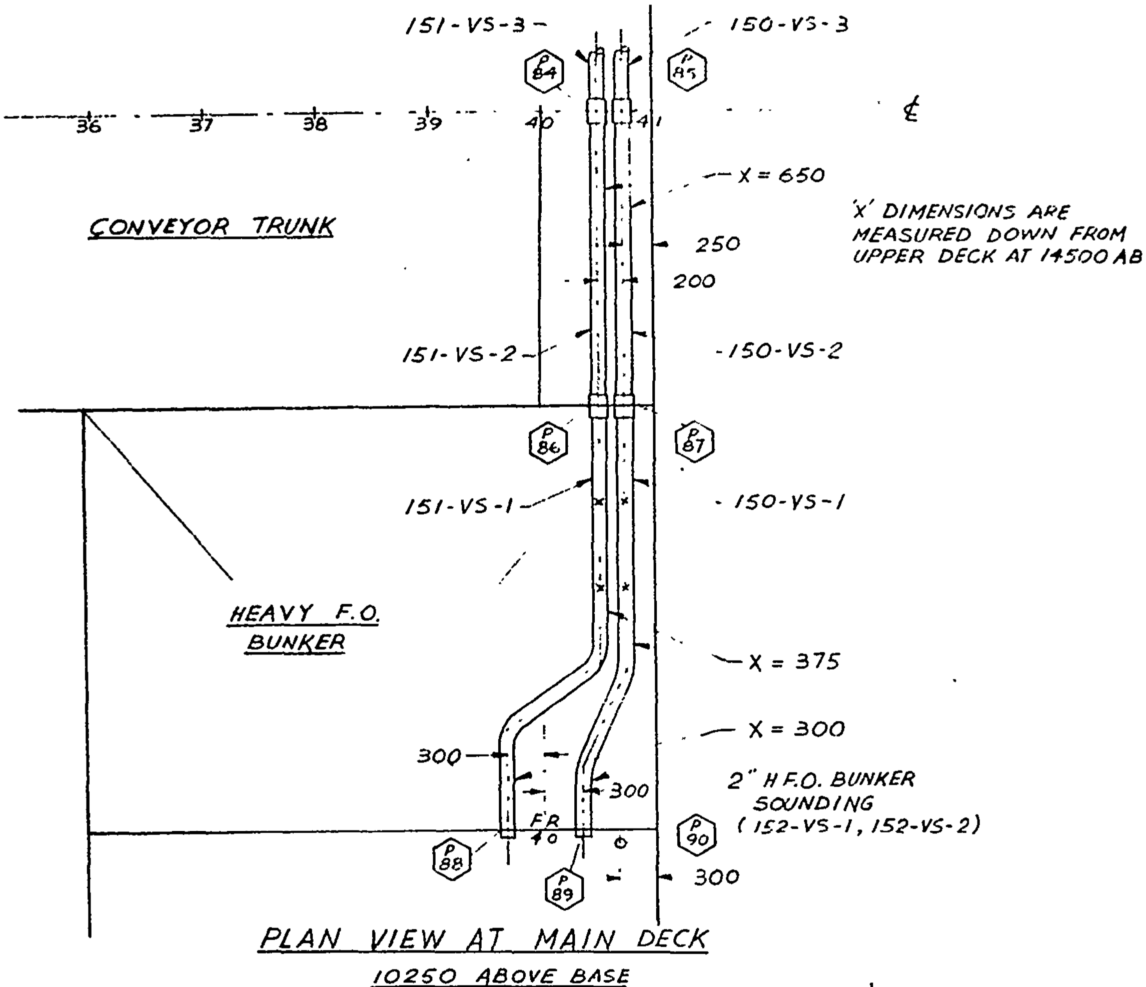
The use of a pipeflanging machine could also introduce considerable saving. Fig. 8 shows a typical vanstone type joint with loose backing rings. Fig. 9 shows the equivalent welded flange joint. The main area of savings lies in the elimination of 2 welded flanges; there is also less material in the flange, and smaller gaskets are used. For a 5" dia. pipe the welding of 2 flanges would take about 84 minutes with manual welding. It is interesting to note the different approach to machine formed flanges in North America and Britain. In North America the approach has been to form a flange in the pipe using a cold spinning process. In Britain the approach has been to hot press the flange. Cold spun flanges as shown in Fig. 8 take about l/2 minute each in the machine. Hot pressed flanges take a little longer - about 2 minutes each.

Further advantages of this type of connection lie in the installation on board ship since the backing rings are loose and the bolt holes can be aligned easily. This type of fitting can be used on bilge and ballast piping, fresh and sea water piping, tank vent piping, and fire and wash-deck piping. It is estimated that on a 30,000 ton bulk carrier, as built in Port Weller, approximately 5000 welded flanges could be replaced by joints of this type.

The material and labour savings accumulated by using pipebenders and profile burners is, in our opinion, sufficient to cover its cost. The production data used by the machine operators could be manually or computer generated. Whatever method is used, however, it is important that the machine operators are not faced with interpreting the data into machine functions. This takes too much time, especially when pipes have a combination of bends and axial rotation or when profile cut pipes require analog settings.

For these reasons the traditional pipe sketches were extended into digitized information for use on pipeshop floor. Fig. 10 shows an extract from a typical pipe system drawing. Fig. 11 shows a typical corresponding pipe sketch for the pipe 151-VS-1. The dimensions of the pipe in relation to the ships baseline, centre line and nearest frame are input into the computer and the digitized information for the bender is output as shown in Fig. 12.

This type of table for use with a pipebender is more or less standard except for the column "minimum bend material".



REV	ZONE	ALTERATION	ISSUE

Title : AIR & SOUNDING ARRGT. (I.M.S) (EXTRACT)		DRG. No 65-2300-3
HULL No. 65	A/C# · 2300	Scale 1 : 50
Drawn by · K.H.	Ch'k'd by ·	Date JUN 28, 79

PORT WELLER DRY DOCKS
A DIVISION OF UPPER LAKES SHIPPING LTD
P.O. BOX 3011 ST CATHARINES ONT L2R 7?1

FIG 10

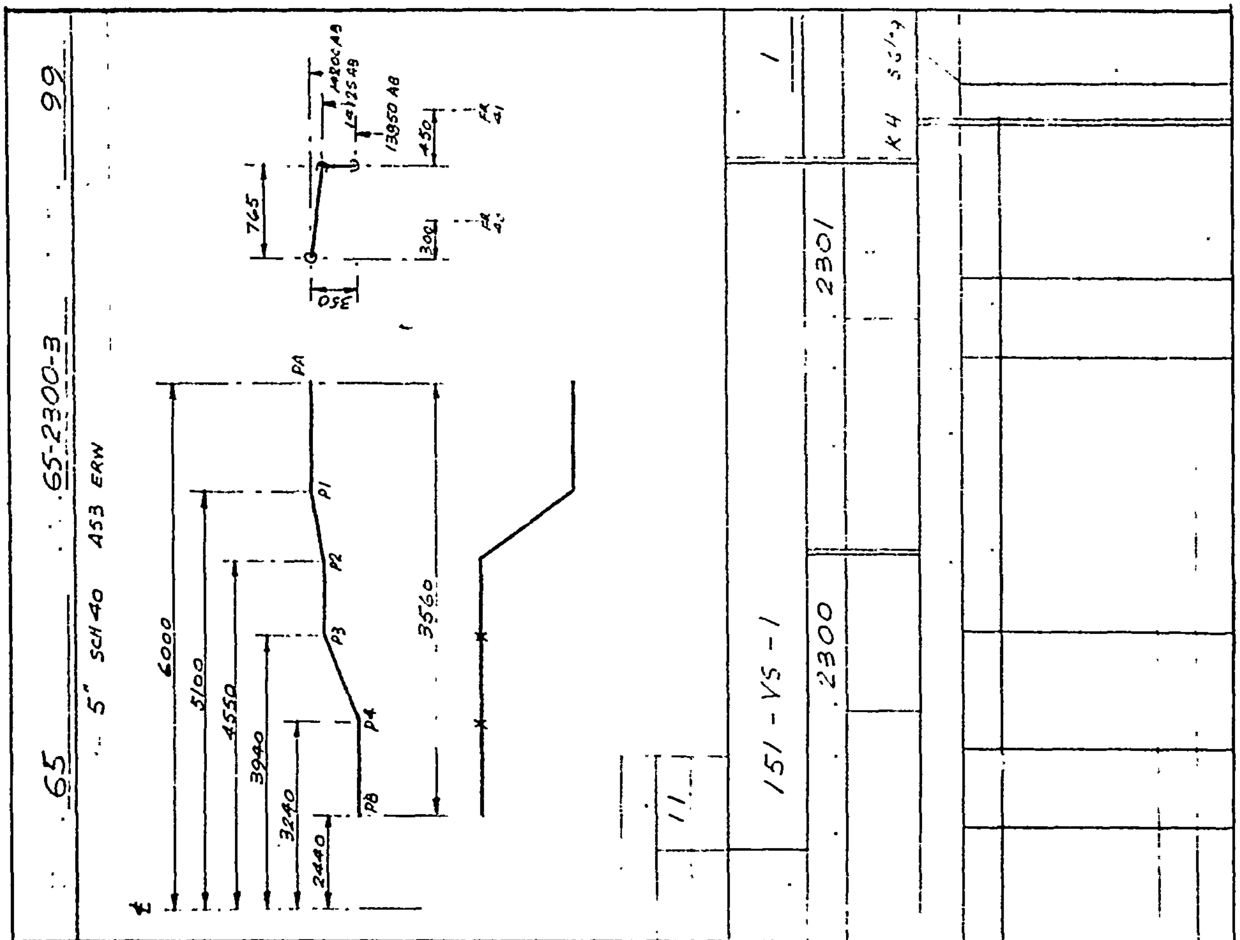


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FIG. 11

PORT WELLER DRY DOCKS - PIPE BENDING DETAILS DATE - 08/01/79 TIME - 10:12:51 SHEET 1 OF DWG. NO.65-2300-3

HULL:65 SYSTEM:AIR & SOUNDING FILE:65VS01 ACCOUNT:2300 INTIALS:K.H.

PIPE DETAIL SHEET NO. 1 TO NO.

PIPE NO.	SOURCE	SIZE (IN)	SCH	WALL (IN)	TYPE	NO.OF BENDS	END A CUT	LTH.TO TANGENT	ROTATION DIAL SET	BEND ANGLE	MIN.BEND MATERIAL	END B CUT	ORD. BETWEEN ENDS X	Y	Z
151-VS-1	STOCK	5.00	40	.258	A53 ERW	4	SQUARE	769.	0.00	54.42	264.		765	-3560	-350
								684.	180.00	54.42	264.				
								431.	275.60	21.45	104.				
								656.	95.60	21.45	104.				
								752.				SQUARE			

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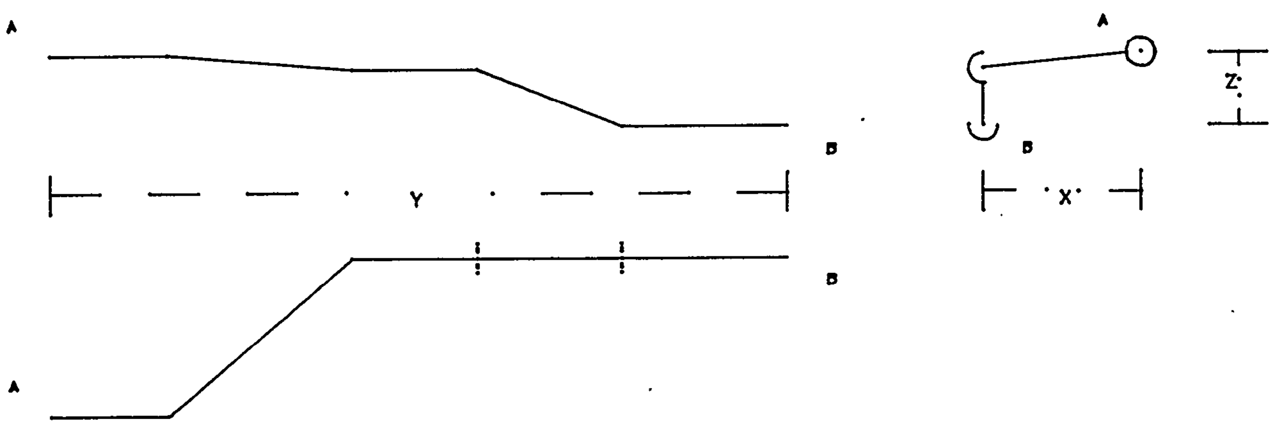
FIG. 12

D1 65 AIR SOUNDING(IMS) 65VS01 2300 0 65-2300-3 JD

D2 151-VS-1 4 S 5.00 40 A53 ERW



SCALE 1: 25. looking to STBD

TIME: 10:40:54
DATE: 08/10/79

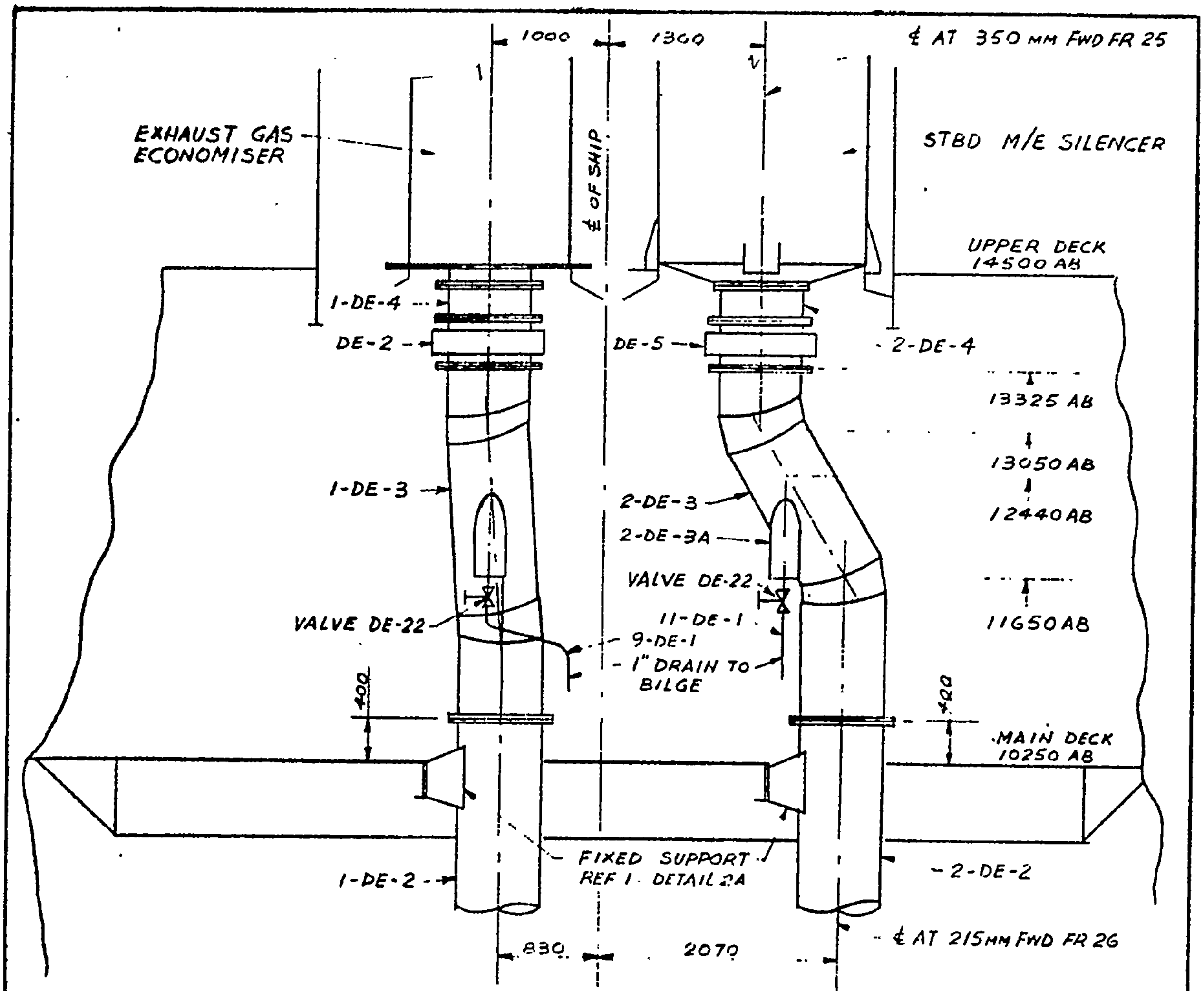
X: 3560. mm
Y: 765. mm
Z: 350. mm

FIG 13

The amount shown in this column is the theoretical minimum amount of pipe that is to be fed into the bend, during the bending operation, to limit the wall-thinning of the outer-bore of the pipe to 14%. This is simply a quality control check dimension measured by a digital read-out display mounted on the bender to indicate that the wall-thinning is within the tolerance.

The same input dimensions used to generate the bending table in Fig. 12 are also fed into a small plotter which draws the pipe sketch as shown in Fig. 13. The work we have done on "plotter produced" pipesketches to date is minimal and has been solely for the purpose of verification of the digitized data used on the shop floor. This verification process is extremely important since a man working' with digitized information on the shop floor is unlikely to recognize incorrect data until he has finished bending the pipe.

For pipes > 8" dia. and ≤ 40" dia. we use digitized information for use with a profile burning machine. Fig. 14 shows an extract from a typical arrangement drawing of large diameter exhaust piping. Fig. 15 shows a typical corresponding pipesketch for use on shop floor. Once again the combination of bends, axial rotation, and offset branch lines can take a considerable amount of interpretation on the shop floor. For this reason the dimensions of the pipes are lifted from the



SECTION AT FR24 LOOKING FORWARD

REV	ZONE	ALTERATION	ISSUE

Title: ARRANGEMENT OF MAIN ENGINE, GENERATOR & BOILER UPTAKE (EXTRACT)		DRG No: 65-2420-1	
HULL No. 65	A/C# · 2420	Scale 1:50	
Drawn by · K.H.	Ch'k'd by	Date .	

PORT WELLER DRY DOCKS

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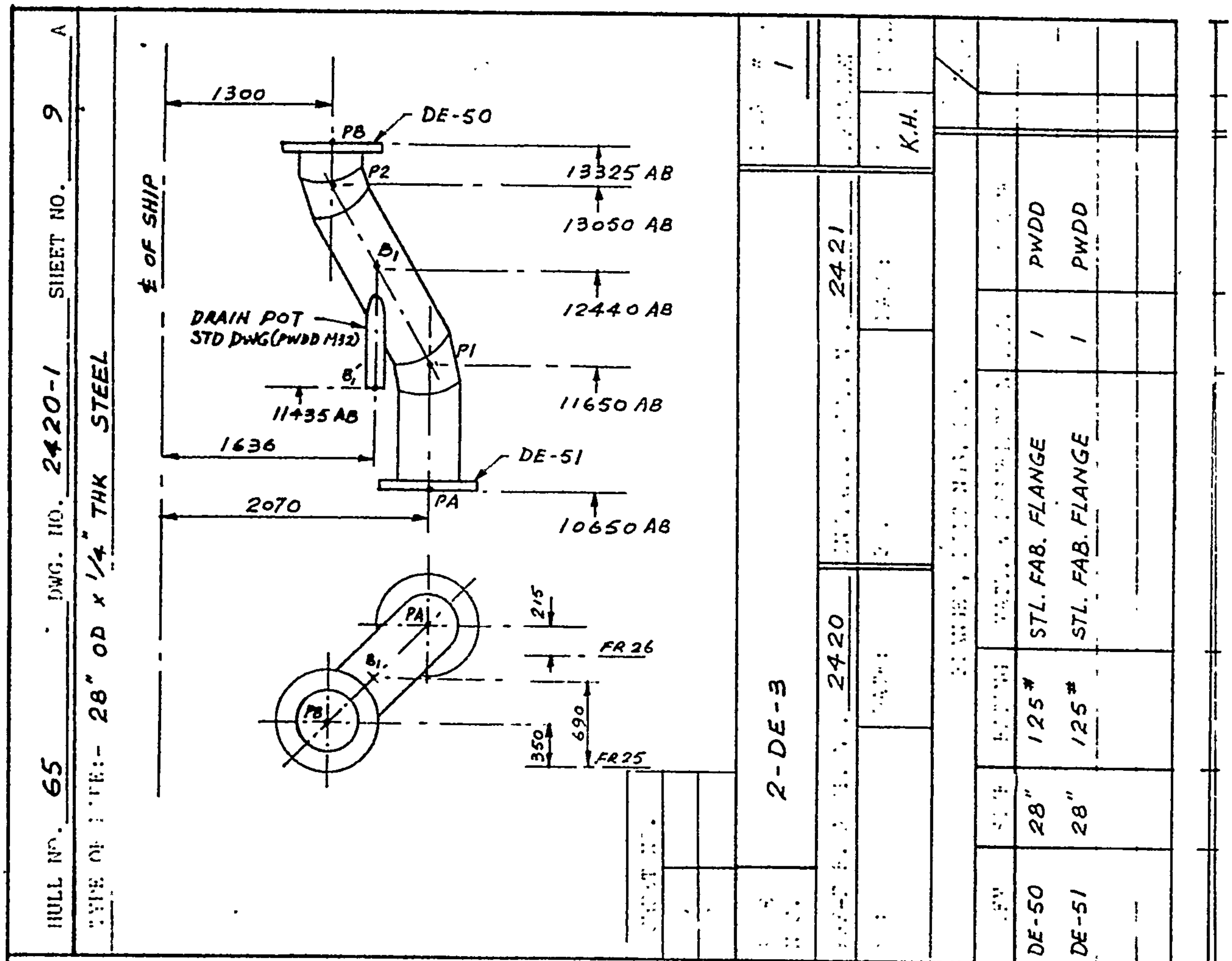
P.O. BOX 3011 ST CATHARINES ONT L2R [illegible]

FIG 14



PORT WELLER DRY DOCKS

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FIG. 15

PORT WELLER DRY DOCKS - PIPE CUTTING DETAILS DATE - 08/01/79 TIME - 10:12:15 SHEET 1 OF DWG. NO.65-2420-1

HULL:65 SYSTEM:MAIN ENGINE EXHAUST FILE:65DE01 ACCOUNT:2420 INITIALS:K.H.

PIPE DETAIL SHEET NO. 9 TO NO.

PIPE NO.	SOURCE	SIZE (IN)	WALL (IN)	TYPE	PC.#	TYPE-OF-CUT	THROAT LENGTH	ROTATION DIAL-SET	BEVEL--SETTINGS HEAD	DIAL	H	ANALOG --- SETTINGS A	B	C	S	SWITCH POSITION D	E	F	X	G
2-DE-3	STOCK	28.00	.250	A53 ERW																
					0/ 1	SLIP-ON	0.	0.0	0.0	0.0	-	-	-	-	-	1	-	3	-	-
					1/ 2	9.5D MITRE	804.	0.0	35.0	90.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
					2/ 3	9.5D MITRE	119.	180.0	35.0	270.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
						38.0D BCH HOLE	156.	180.0	0.0	0.0	-	227.3	81.3	103.3	0.0	2	1	4	2	1
					3/ 4	9.5D MITRE	1407.	.0	35.0	90.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
					4/ 5	9.5D MITRE	119.	180.0	35.0	270.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
					5/ 6	SLIP-ON	79.	180.0	0.0	0.0	-	-	-	-	-	1	-	3	-	-
2-DE-3A	STOCK	10.00	.365	A53 ERW																
					0/ 1	38.0D CONTOUR	349.	0.0	52.0	0.0	94.	288.6	103.3	81.3	0.0	1	1	4	2	2
					1/ 2	SQUARE	265.	0.0	0.0	0.0	-	-	-	-	-	1	-	3	-	-

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FIG. 16

pipe arrangement drawing and input into the computer. The digitized information, as shown in Fig. 16, is the output and consists of pipe identification data, analog settings, and switch positions required to generate each part.

The system described in this paper represents a "first step" towards semi-automatic pipe fabrication in a small shipyard. We recognize that the computer programs are somewhat limited, however it should be noted that all that was required to generate these programs was access to a Fortran Program, a lineprinter, a small plotter, and a small amount of programming time. The programs are small, inexpensive to run, and represent our initial attempts to support semi-automatic pipe production equipment with computer derived production data.

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