US 20100217536A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2010/0217536 A1
(43) Pub. Date: Aug. 26, 2010
Casimiro et al.

(54) BUNKER FUEL TRANSFER

(75) Inventors: **Richard P. Casimiro**, North Kingstown, RI (US); **Mihaela D. Duta**, Crescent (GB); **Manus P. Henry**, Oxford (GB); **Michael S. Tombs**, Oxford (GB); **Feibiao B. Zhou**, Oxford (GB)

Correspondence Address:
FISH & RICHARDSON P.C.
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022 (US)

(73) Assignee: **Invensys Systems, Inc.**, Foxboro, MA (US)

(21) Appl. No.: **12/536,541**

(22) Filed: **Aug. 6, 2009**

Related U.S. Application Data

(60) Provisional application No. 61/155,883, filed on Feb. 26, 2009, provisional application No. 61/181,963, filed on May 28, 2009.

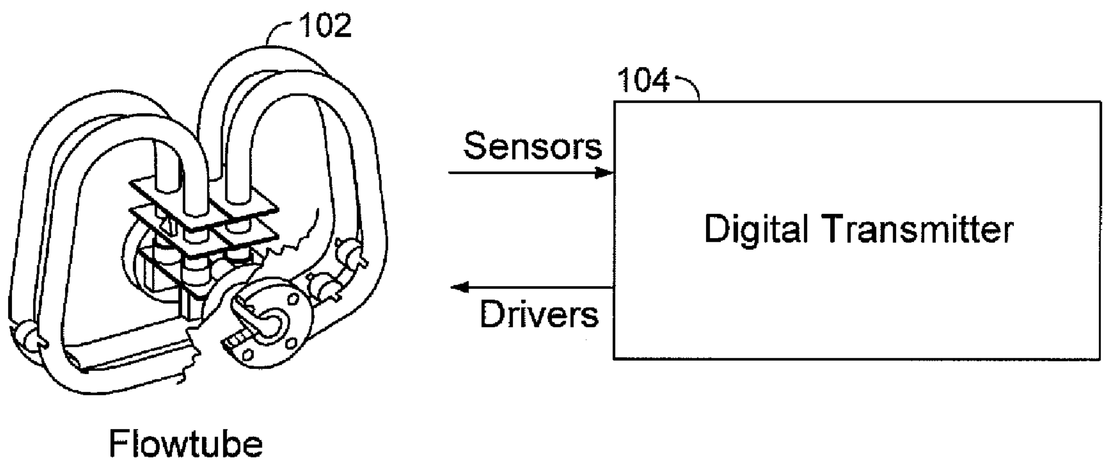
Publication Classification

(51) **Int. Cl.**
G01F 1/00 (2006.01)
G06F 19/00 (2006.01)

(52) **U.S. Cl.** **702/25**; 702/45

(57) **ABSTRACT**

A bunker fuel transfer system that includes a multi-measurement metering system and bunkering receipt issuing equipment (BRIE). The bunker fuel transfer system can be installed on either the bunker barge or the ship receiving the bunker fuel. Various implementations can provide for quantity certainty of bunker fuel delivery transactions, and can provide for automated bunker fuel transfer reports. The bunker fuel transfer reports can include details and trends of the bunker fuel transfers to allow for quantity measurement validation. In addition, some implementations may provide for quality validation by including pertinent measurements, which can be included in the reports.



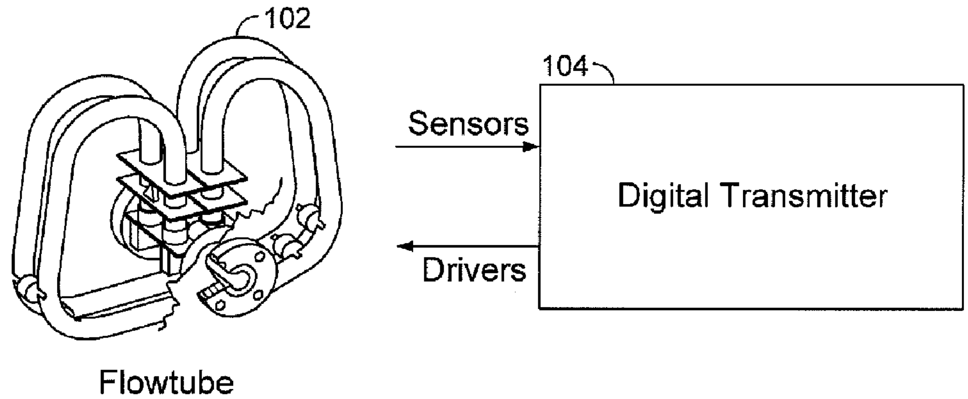

102
104
Sensors
Digital Transmitter
Drivers
Flowtube

FIG. 1A

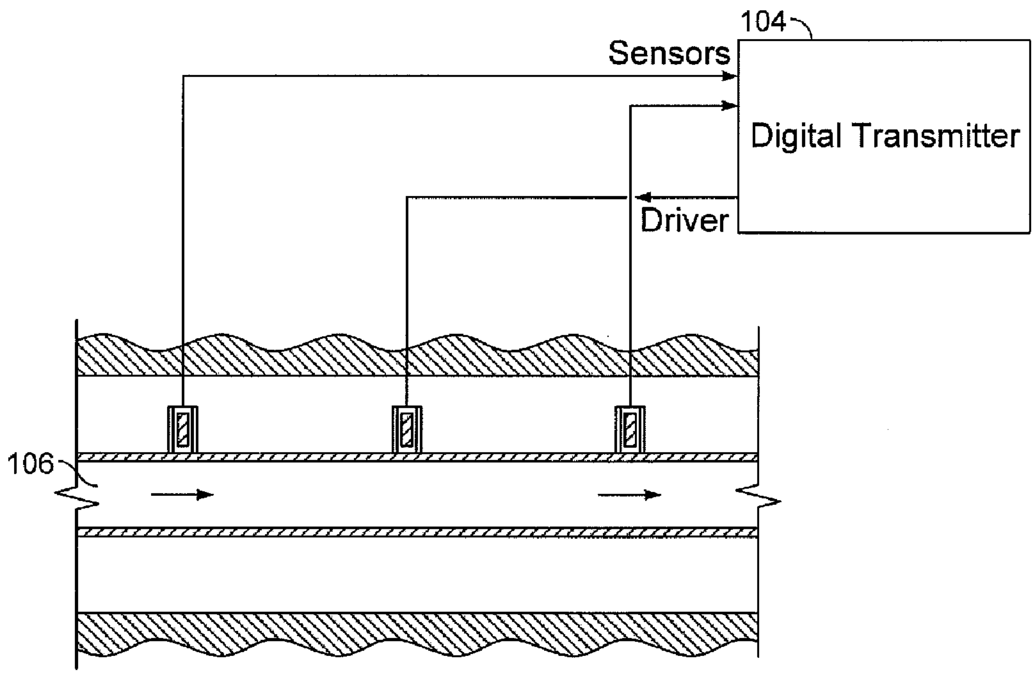

104
Sensors
Digital Transmitter
Driver
106

FIG. 1B

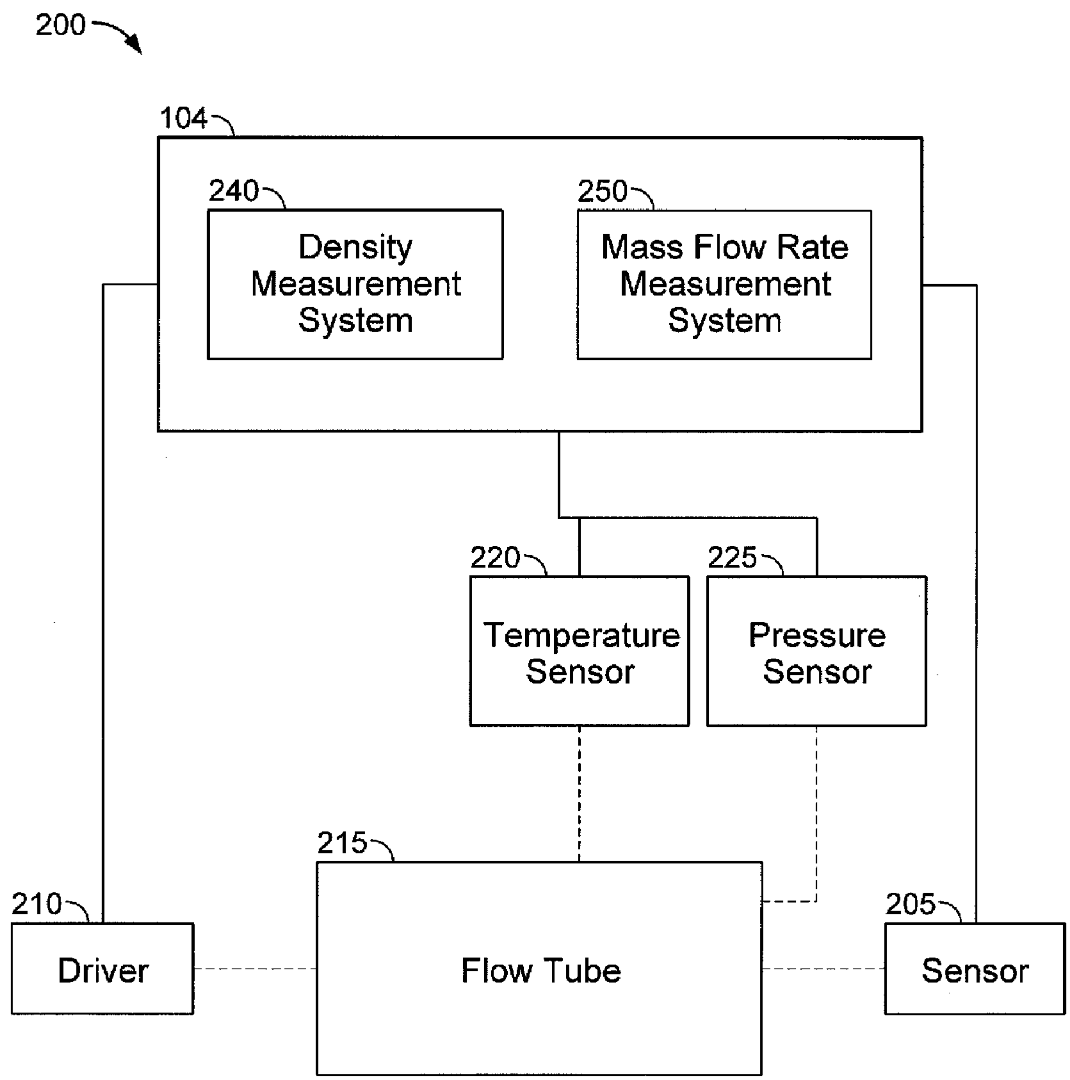

200
104
240
Density Measurement System
250
Mass Flow Rate Measurement System
220
Temperature Sensor
225
Pressure Sensor
215
Flow Tube
210
Driver
205
Sensor

FIG. 2

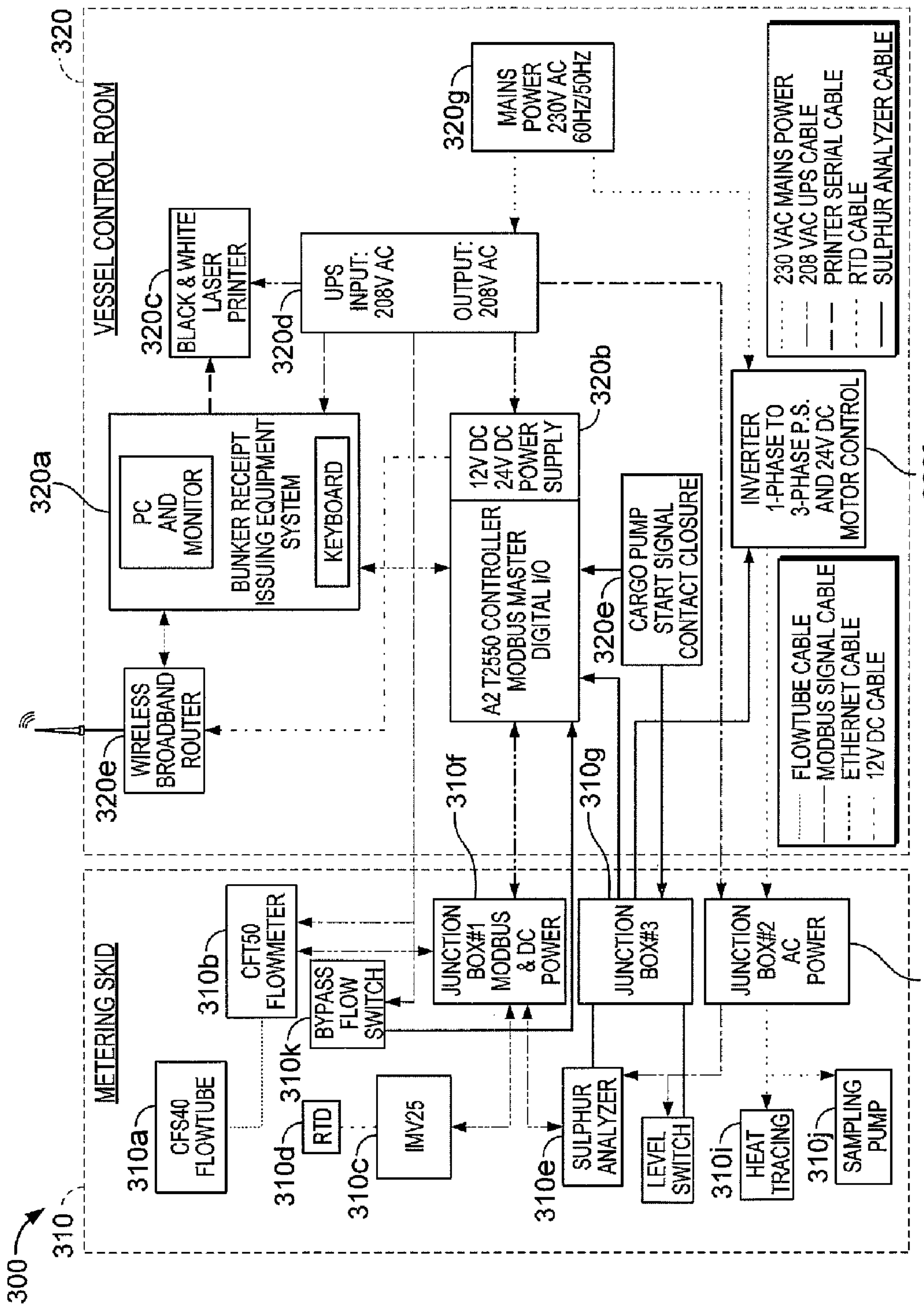

300
310
METERING SKID
320
VESSEL CONTROL ROOM
310a CFS40 FLOWTUBE
310b CFT50 FLOWMETER
310k BYPASS FLOW SWITCH
310d RTD
310c IMV25
310e SULPHUR ANALYZER
LEVEL SWITCH
310i HEAT TRACING
310j SAMPLING PUMP
310f JUNCTION BOX#1 MODBUS & DC POWER
310g JUNCTION BOX#3
310h JUNCTION BOX#2 AC POWER
320e WIRELESS BROADBAND ROUTER
320a PC AND MONITOR
BUNKER RECEIPT ISSUING EQUIPMENT SYSTEM
KEYBOARD
320c BLACK & WHITE LASER PRINTER
320d UPS INPUT: 208V AC OUTPUT: 208V AC
320g MAINS POWER 230V AC 60HZ/50HZ
A2 T2550 CONTROLLER MODBUS MASTER DIGITAL I/O
320b 12V DC 24V DC POWER SUPPLY
320e CARGO PUMP START SIGNAL CONTACT CLOSURE
320f INVERTER 1-PHASE TO 3-PHASE P.S. AND 24V DC MOTOR CONTROL
FLOWTUBE CABLE
MODBUS SIGNAL CABLE
ETHERNET CABLE
12V DC CABLE
230 VAC MAINS POWER
208 VAC UPS CABLE
PRINTER SERIAL CABLE
RTD CABLE
SULPHUR ANALYZER CABLE

FIG. 3

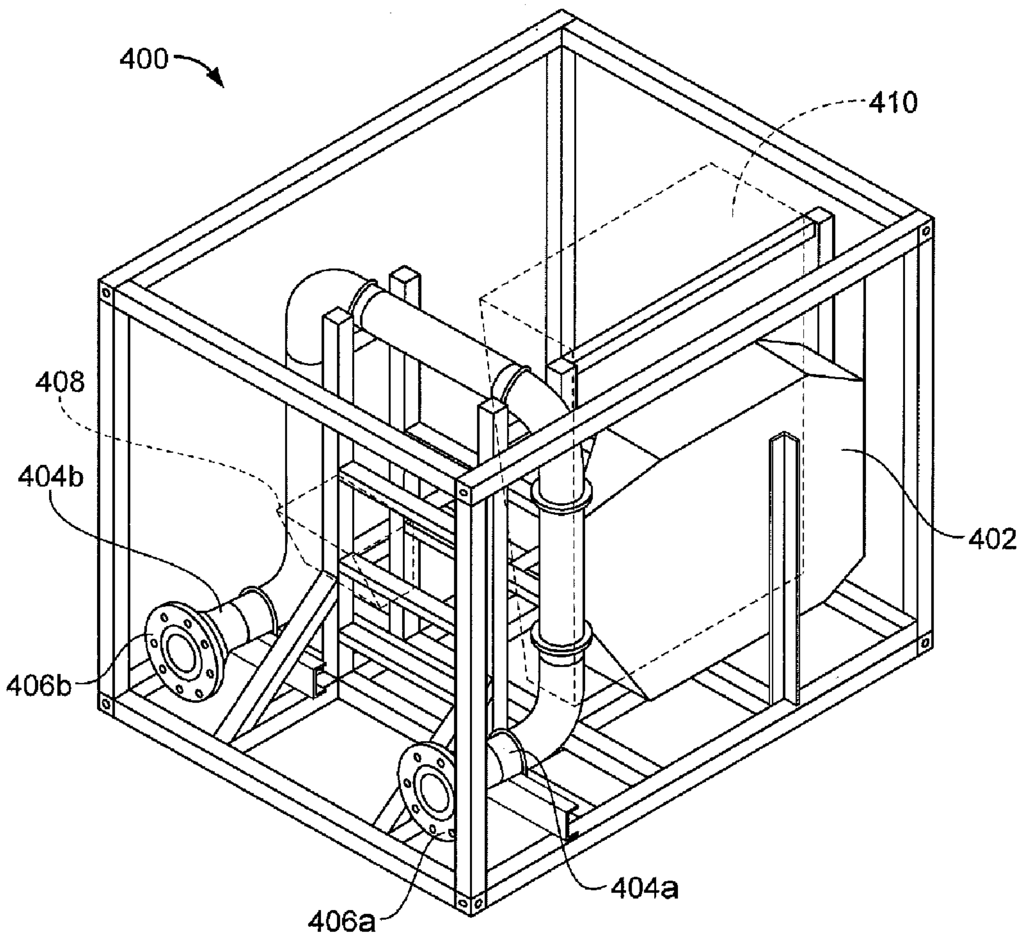


FIG. 4

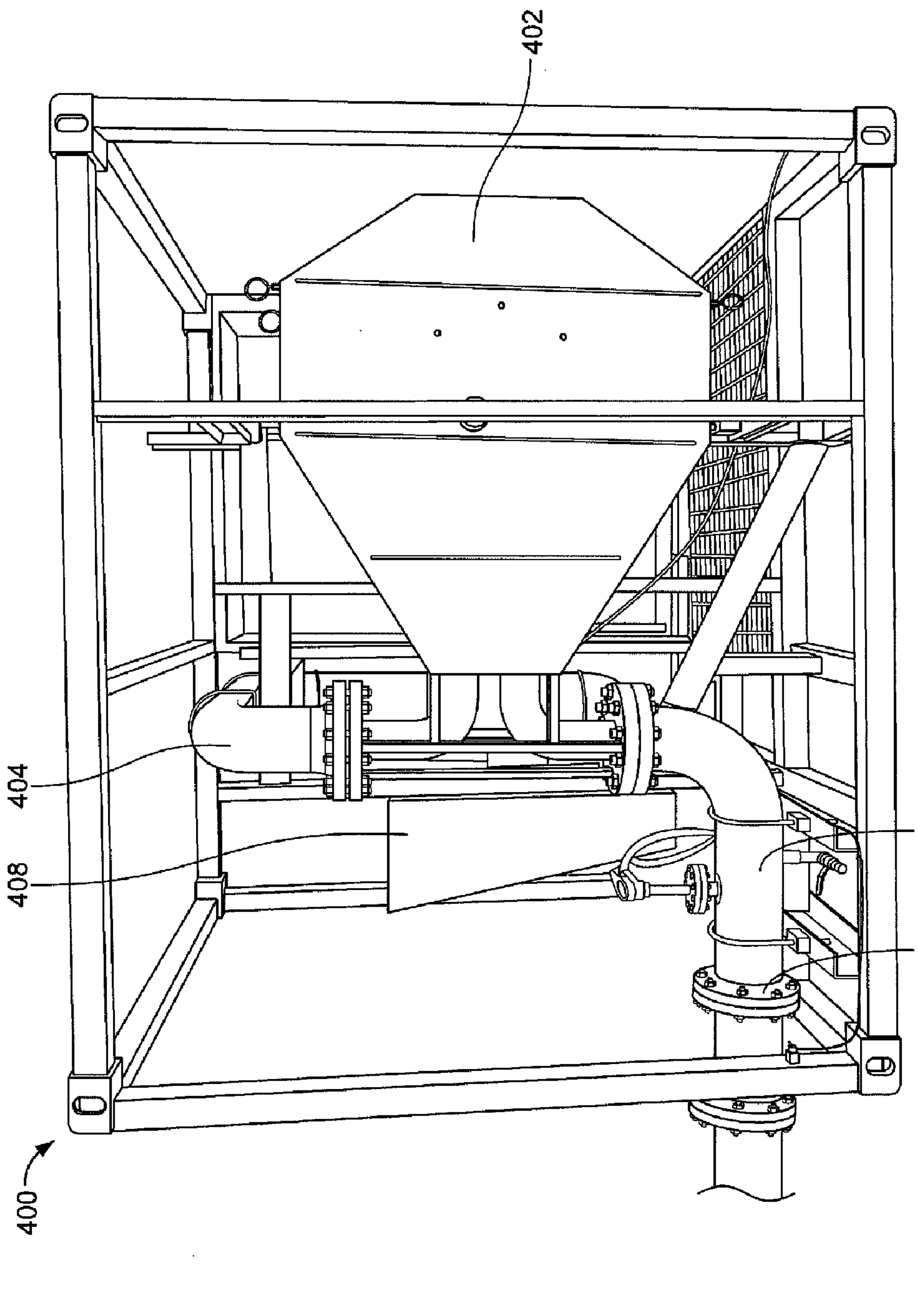


FIG. 5

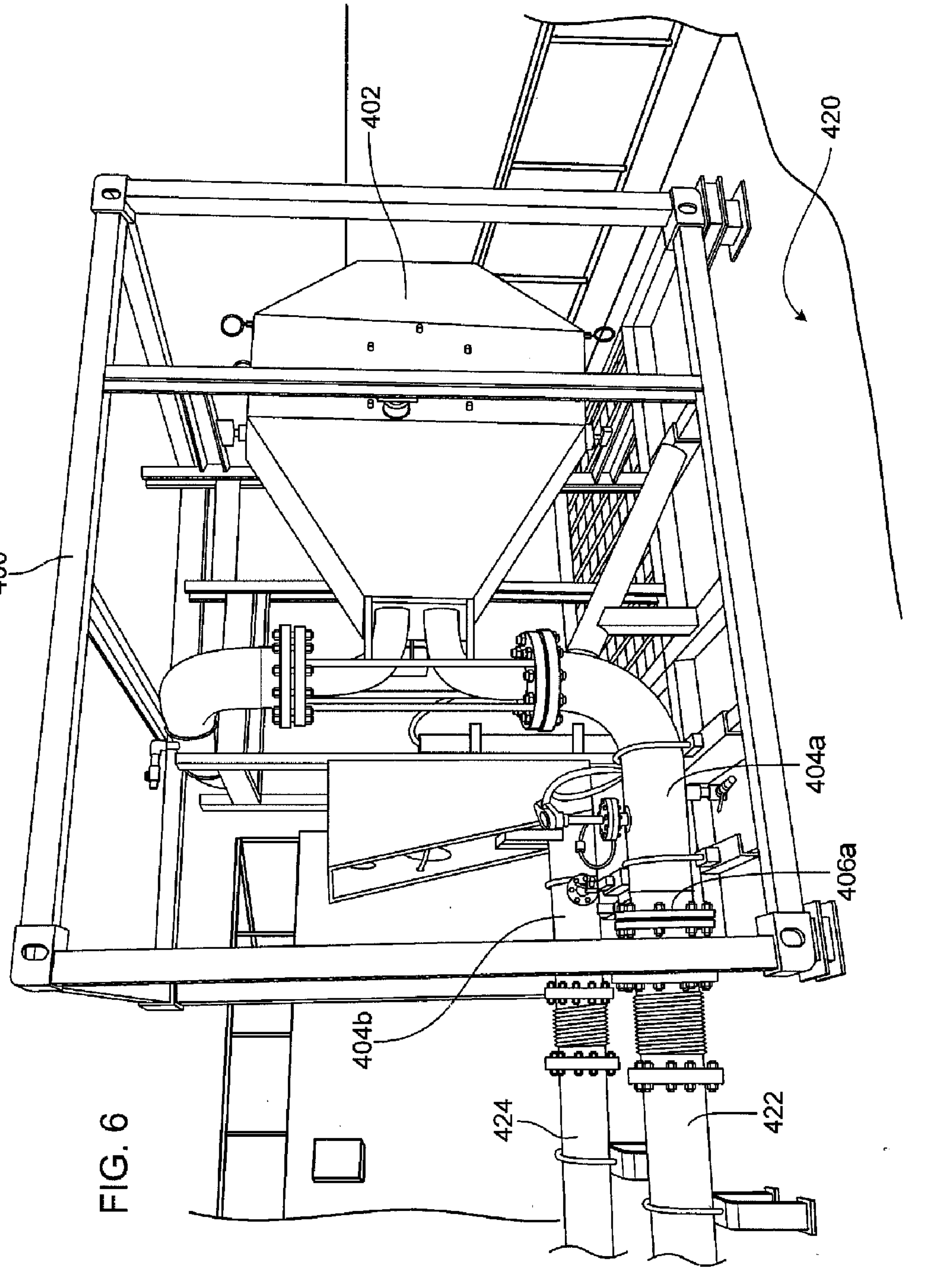


FIG. 6

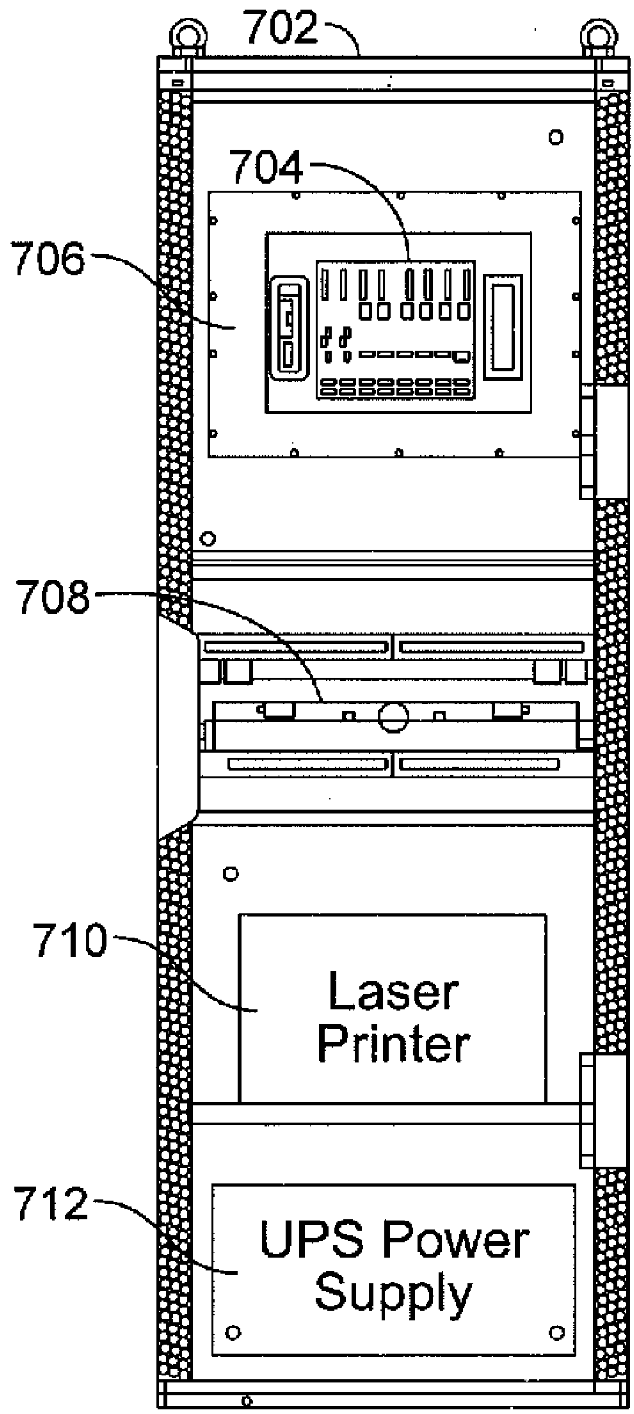


FIG. 7

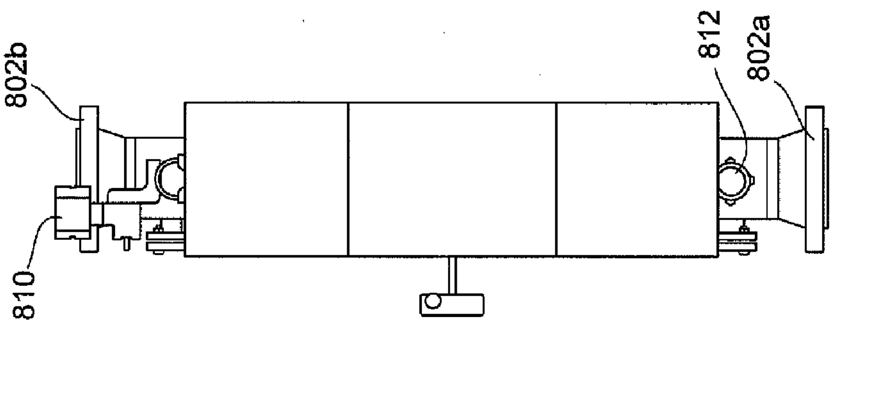

802b
810
812
802a

FIG. 8B

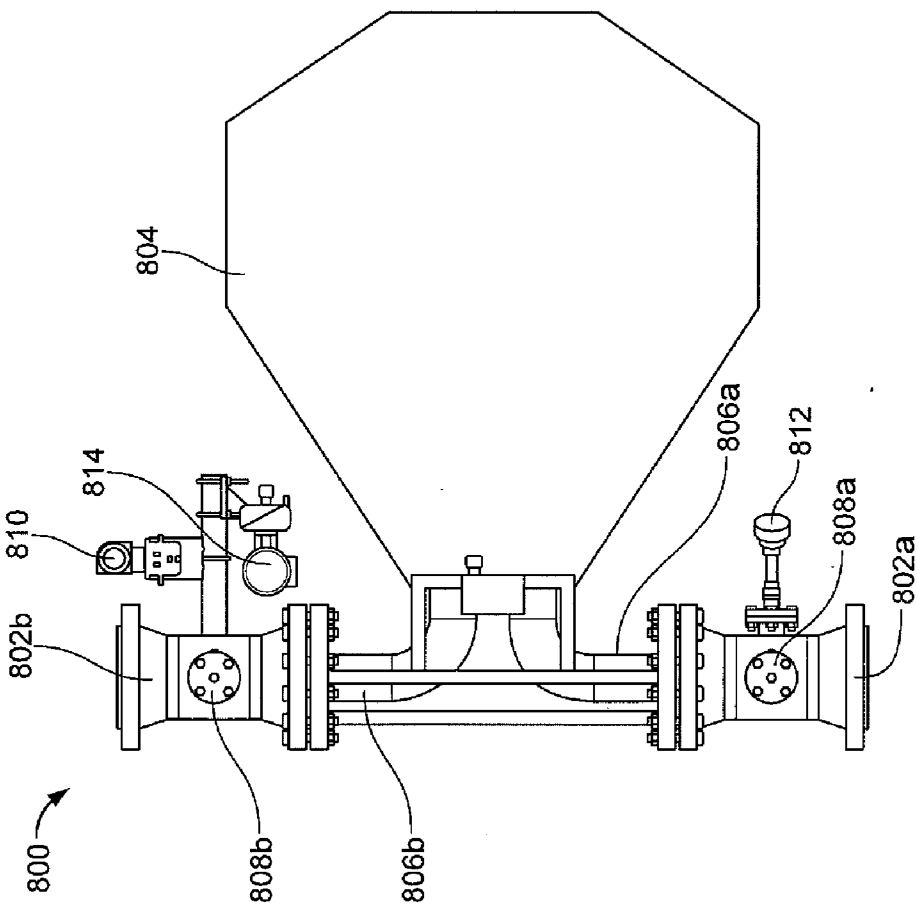

800
802b
810
814
804
806a
812
808a
802a
808b
806b

FIG. 8A

900

BUNKER TRANSFER REPORT

TRANSFER INFO

902

PORT NAME	SINGAPORE
BARGE NAME	
VESSEL NAME AND IMO	
PRODUCT ID	UNKNOWN
TRANSACTION NUMBER	1
TRANSFER START TIME	SEP.03,2008 04:30:01
TRANSFER END TIME	SEP.03,2008 10:59:58
DURATION OF TRANSFER [HH:MM:SS]	06:29:57

BATCH REGISTERS

904

TOTAL MASS IN TRANSFER [KG]	1284122.95

QUALITY DATA

906

MEASUREMENT	MASS WEIGHTED AVERAGE	MIN VALUE	MAX VALUE
FLUID TEMPERATURE [°C]	38.01	30.62	42.72
INLET PRESSURE [BARG]	6.04	0.10	7.39
FLUID MIXTURE DENSITY [KG/M^3]	973.02	180.77	980.20
LIQUID DENSITY AT LINE COND [KG/M^3]	977.20	180.77	980.20
SULPHUR CONTENT [%]	0.00	N/A	N/A
VISCOSITY [%]	0.00	N/A	N/A

FIG. 9A

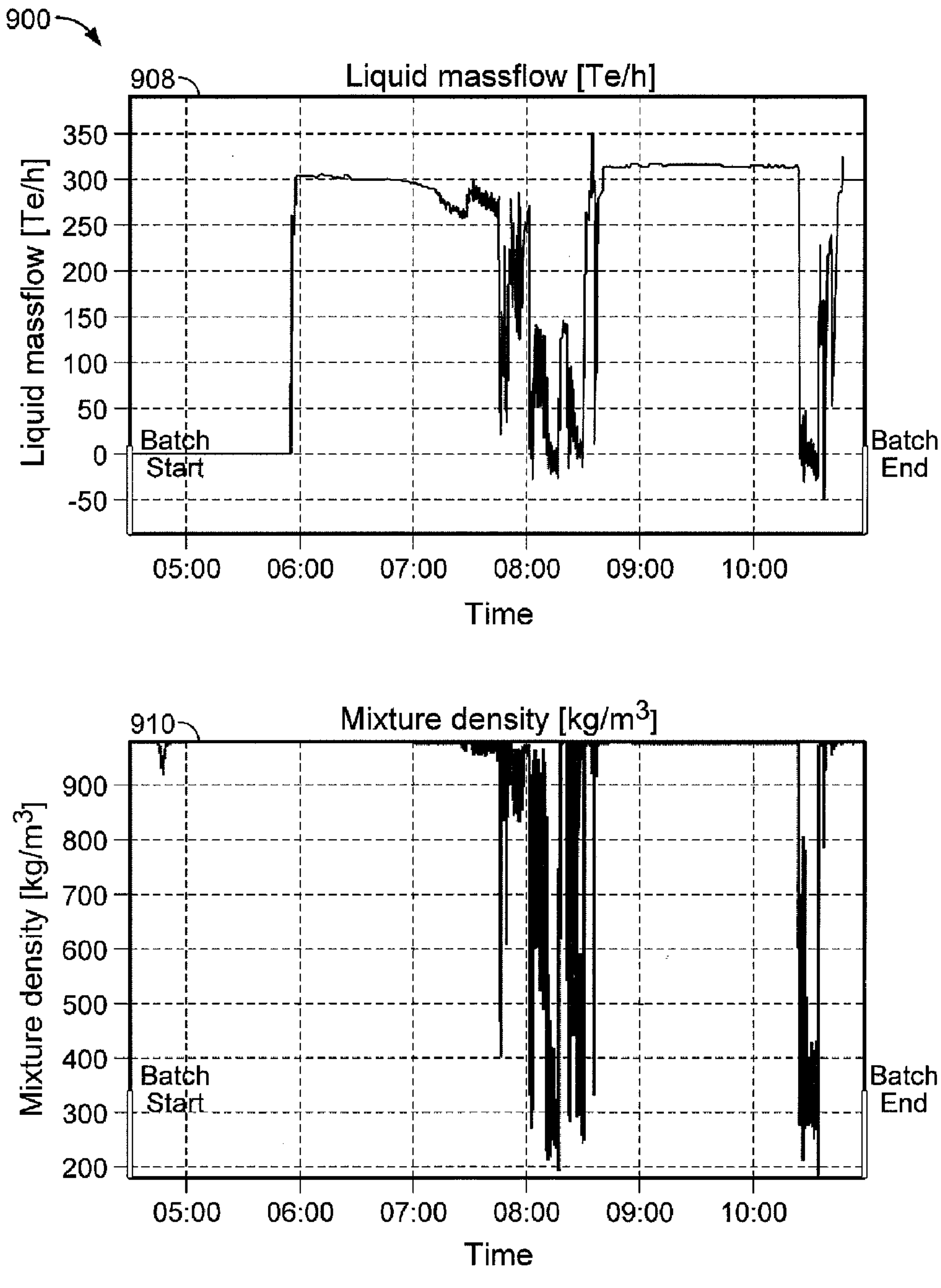

900
908
Liquid massflow [Te/h]
Liquid massflow [Te/h]
350
300
250
200
150
100
50
0
-50
Batch Start
Batch End
05:00
06:00
07:00
08:00
09:00
10:00
Time
910
Mixture density [kg/m3]
Mixture density [kg/m3]
900
800
700
600
500
400
300
200
Batch Start
Batch End
05:00
06:00
07:00
08:00
09:00
10:00
Time

FIG. 9B

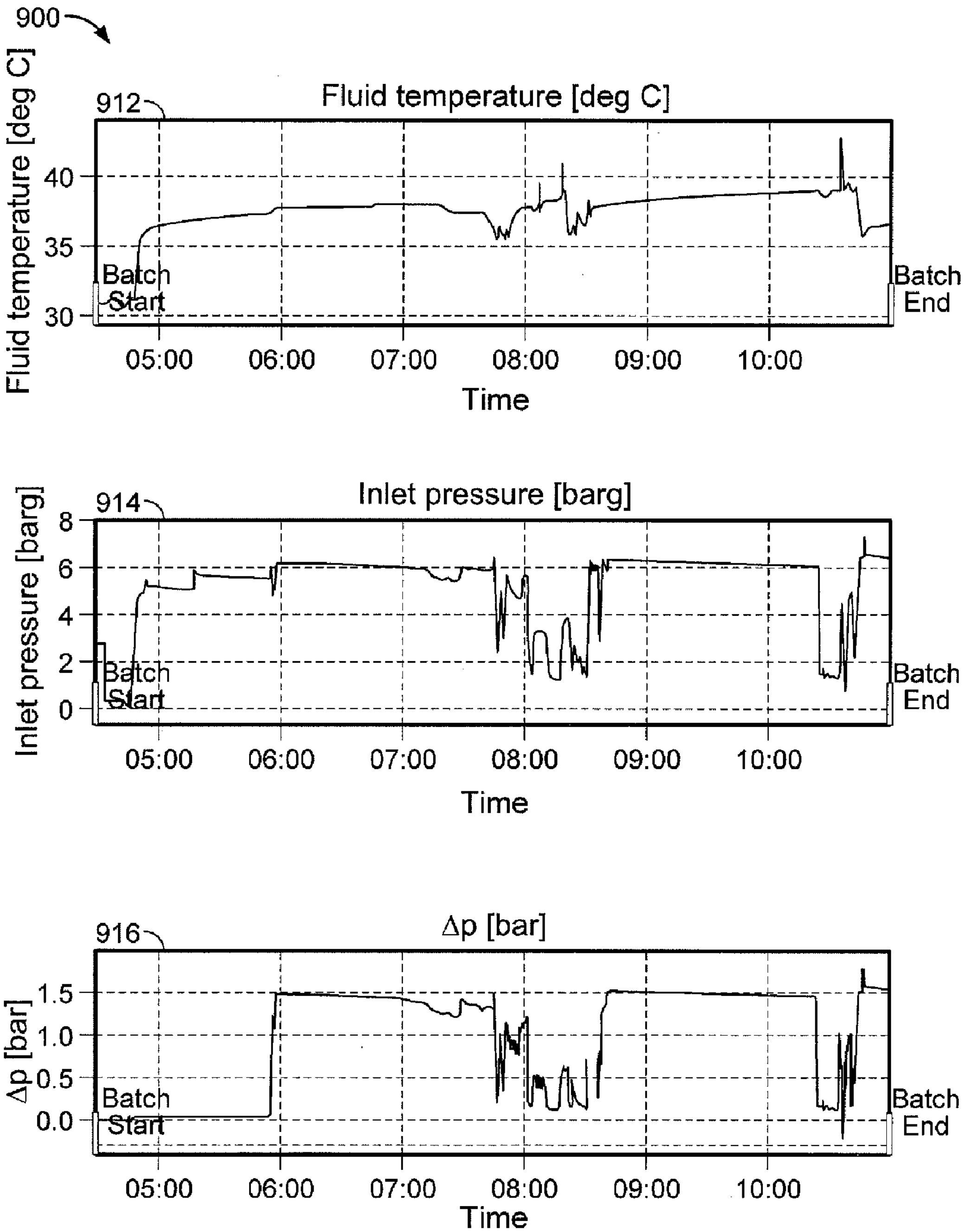

900
912
Fluid temperature [deg C]
Fluid temperature [deg C]
40
35
30
Batch Start
Batch End
05:00
06:00
07:00
08:00
09:00
10:00
Time
914
Inlet pressure [barg]
Inlet pressure [barg]
8
6
4
2
0
Batch Start
Batch End
05:00
06:00
07:00
08:00
09:00
10:00
Time
916
Δp [bar]
Δp [bar]
1.5
1.0
0.5
0.0
Batch Start
Batch End
05:00
06:00
07:00
08:00
09:00
10:00
Time

FIG. 9C

1000

BUNKER TRANSFER REPORT

TRANSFER INFO

1002

PORT NAME	SINGAPORE
BARGE NAME	
VESSEL NAME AND IMO	
PRODUCT ID	
TRANSACTION NUMBER	1
BUNKER FUEL CERTIFICATE STANDARD DENSITY [KG/M^3]	990.700
TRANSFER START TIME	04-SEP-2008 08:25
TRANSFER END TIME	04-SEP-2008 11:15
DURATION OF TRANSFER [HH:MM]	02:50

BATCH REGISTERS

1004

TOTAL MASS IN TRANSFER [TE]	629.172
TOTAL APPARENT MASS IN AIR (TABLE 56) [TE]	628.492
TOTAL MASS TRANSFERRED IN SINGLE-PHASE [TE]	605.489
TOTAL MASS TRANSFERRED IN TWO-PHASE [TE]	23.683
TOTAL MASS TRANSFERRED IN TWO-PHASE [%]	3.8

QUALITY DATA

1006

MEASUREMENT	MASS WEIGHTED AVERAGE	MIN VALUE	MAX VALUE
FLUID TEMPERATURE [°C]	37.5	27.7	40.3
INLET PRESSURE [BARG]	5.5	0.2	6.3
FLUID MIXTURE DENSITY [KG/M^3]	977.7	135.4	982.3
LIQUID DENSITY AT LINE COND [KG/M^3]	978.9	135.4	982.3
SULPHUR CONTENT [%]	0.00	N/A	N/A
VISCOSITY [%]	0.00	N/A	N/A

FIG. 10A

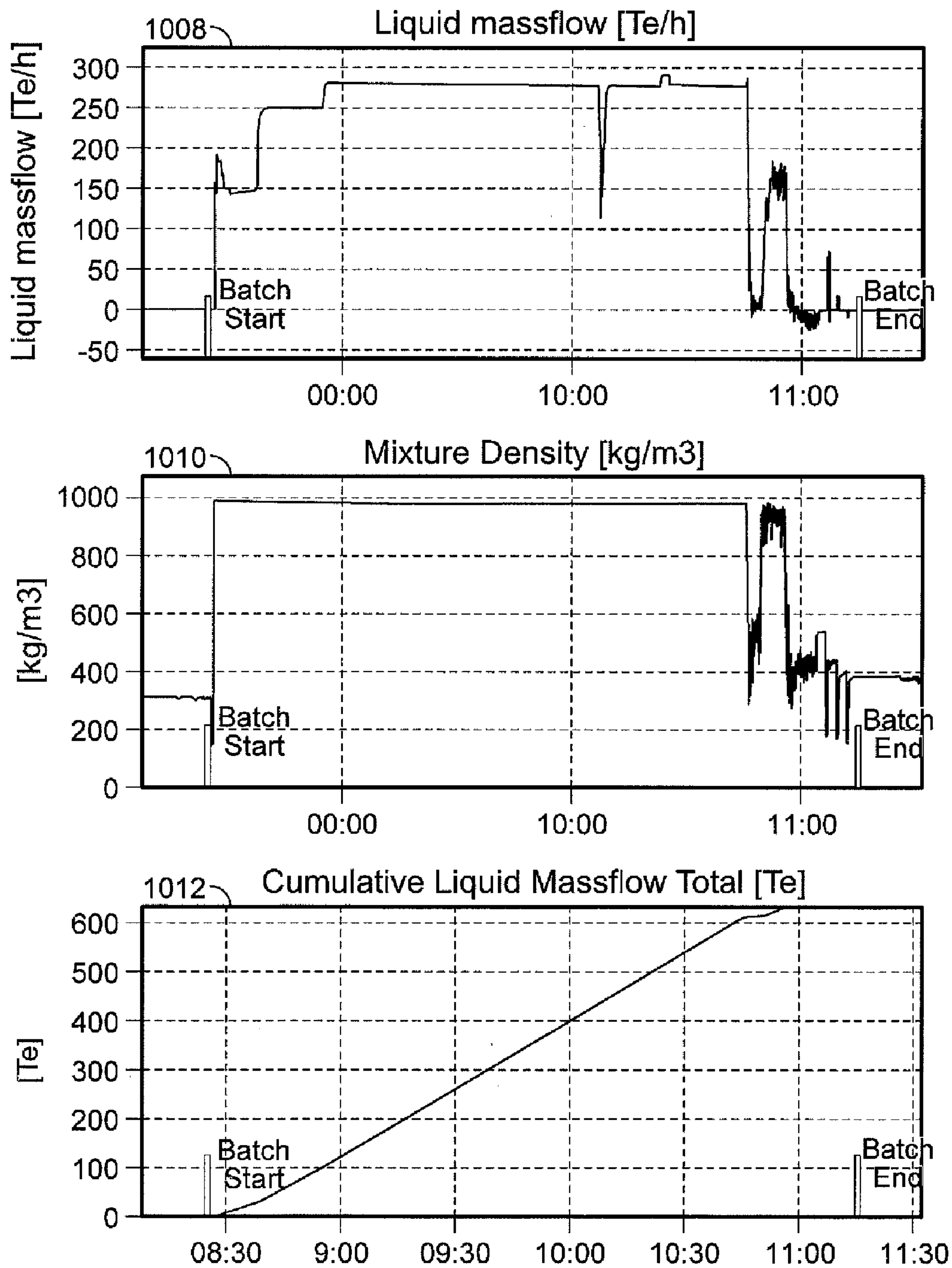

1008
Liquid massflow [Te/h]
Liquid massflow [Te/h]
300
250
200
150
100
50
0
-50
Batch Start
Batch End
00:00
10:00
11:00
1010
Mixture Density [kg/m3]
[kg/m3]
1000
800
600
400
200
0
Batch Start
Batch End
00:00
10:00
11:00
1012
Cumulative Liquid Massflow Total [Te]
[Te]
600
500
400
300
200
100
0
Batch Start
Batch End
08:30
9:00
09:30
10:00
10:30
11:00
11:30

FIG. 10B

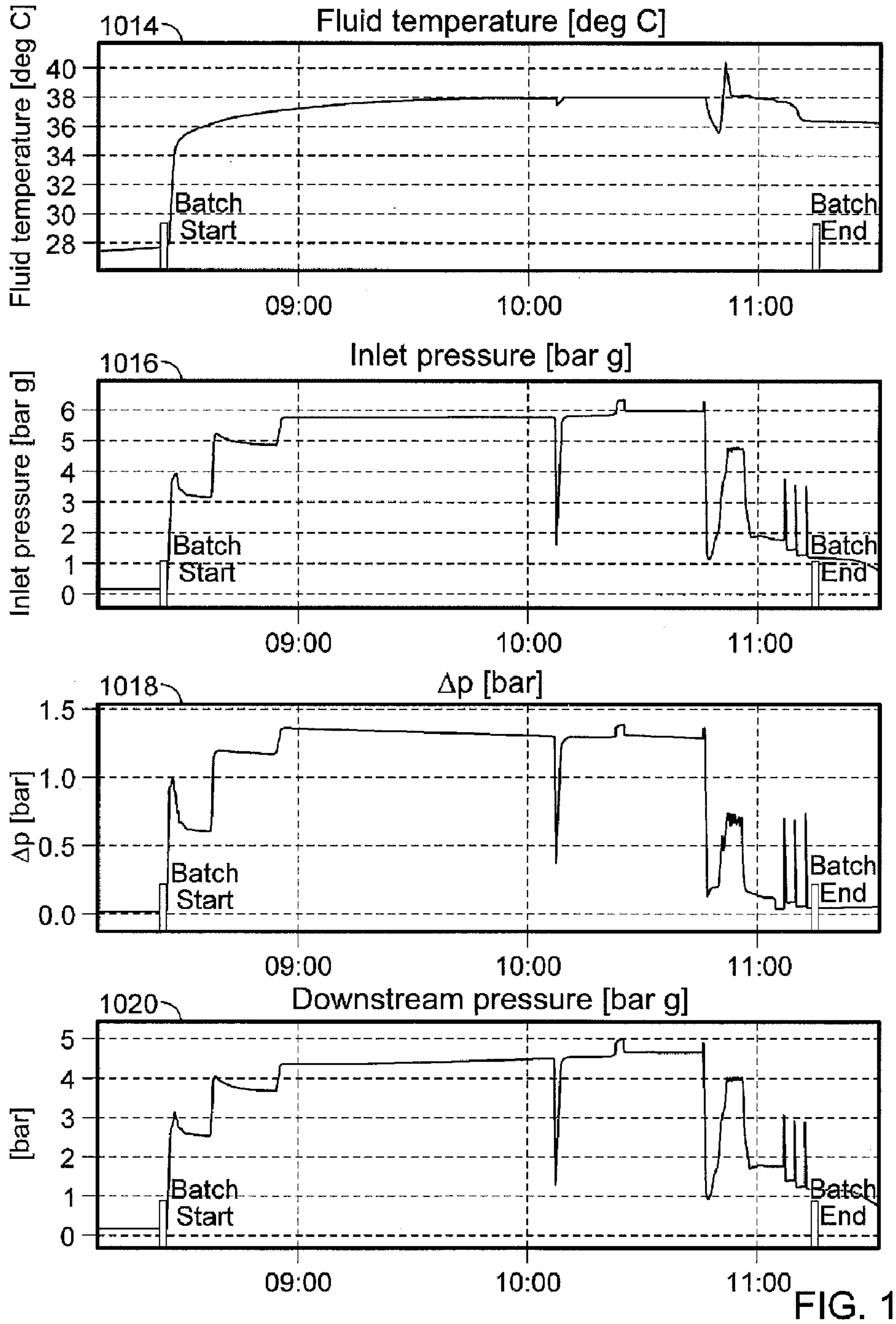
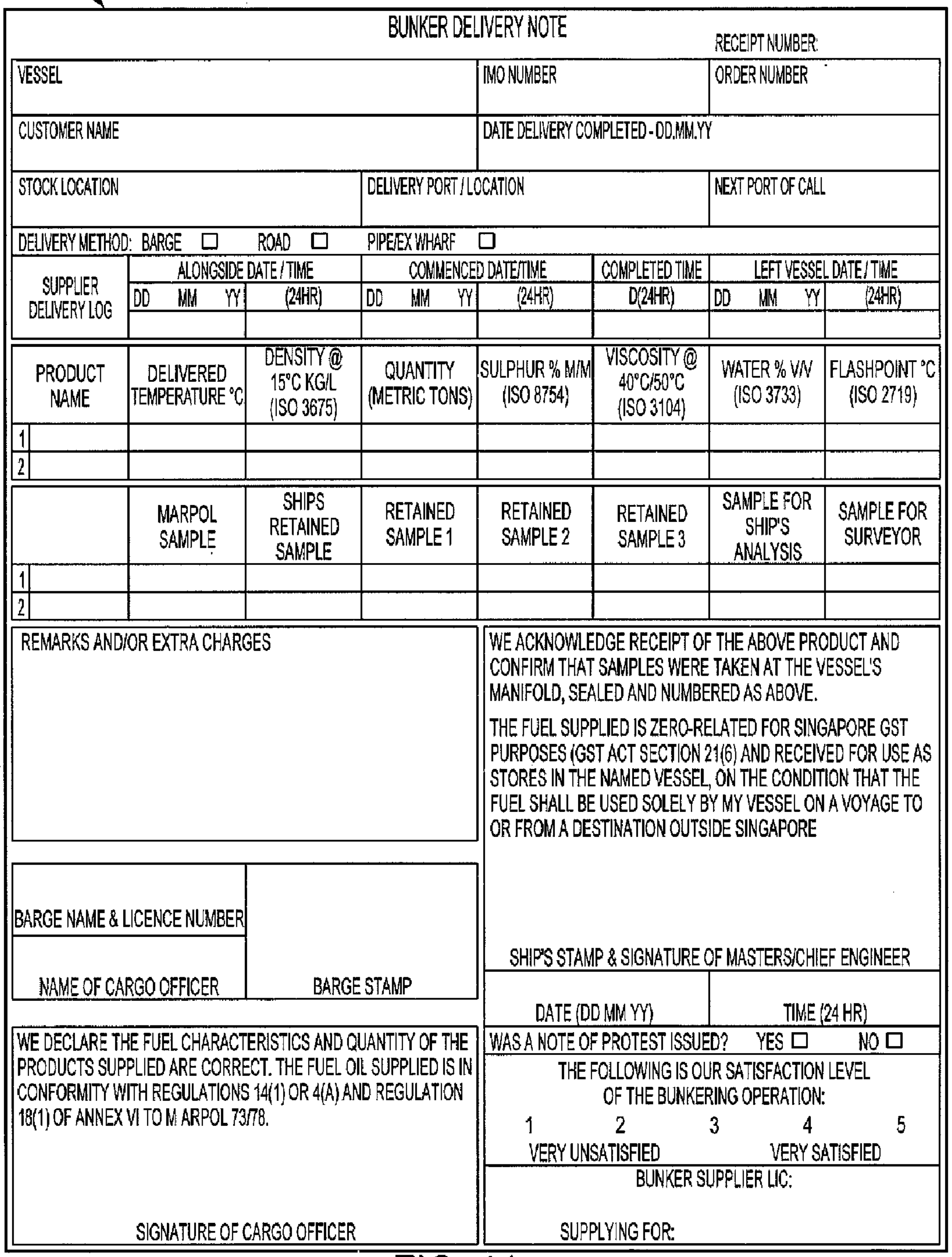

1014
Fluid temperature [deg C]
Fluid temperature [deg C]
40
38
36
34
32
30
28
Batch Start
Batch End
09:00
10:00
11:00
1016
Inlet pressure [bar g]
Inlet pressure [bar g]
6
5
4
3
2
1
0
Batch Start
Batch End
09:00
10:00
11:00
1018
Δp [bar]
Δp [bar]
1.5
1.0
0.5
0.0
Batch Start
Batch End
09:00
10:00
11:00
1020
Downstream pressure [bar g]
[bar]
5
4
3
2
1
0
Batch Start
Batch End
09:00
10:00
11:00

FIG. 10C

1100



BUNKER DELIVERY NOTE

RECEIPT NUMBER:

VESSEL	IMO NUMBER	ORDER NUMBER
CUSTOMER NAME	DATE DELIVERY COMPLETED - DD.MM.YY	
STOCK LOCATION	DELIVERY PORT / LOCATION	NEXT PORT OF CALL

DELIVERY METHOD: BARGE ☐ ROAD ☐ PIPE/EX WHARF ☐

SUPPLIER DELIVERY LOG	ALONGSIDE DATE / TIME		COMMENCED DATE/TIME		COMPLETED TIME	LEFT VESSEL DATE / TIME	
	DD MM YY	(24HR)	DD MM YY	(24HR)	D(24HR)	DD MM YY	(24HR)

PRODUCT NAME	DELIVERED TEMPERATURE °C	DENSITY @ 15°C KG/L (ISO 3675)	QUANTITY (METRIC TONS)	SULPHUR % M/M (ISO 8754)	VISCOSITY @ 40°C/50°C (ISO 3104)	WATER % V/V (ISO 3733)	FLASHPOINT °C (ISO 2719)
1							
2							

	MARPOL SAMPLE	SHIPS RETAINED SAMPLE	RETAINED SAMPLE 1	RETAINED SAMPLE 2	RETAINED SAMPLE 3	SAMPLE FOR SHIP'S ANALYSIS	SAMPLE FOR SURVEYOR
1							
2							

REMARKS AND/OR EXTRA CHARGES

WE ACKNOWLEDGE RECEIPT OF THE ABOVE PRODUCT AND CONFIRM THAT SAMPLES WERE TAKEN AT THE VESSEL'S MANIFOLD, SEALED AND NUMBERED AS ABOVE.

THE FUEL SUPPLIED IS ZERO-RELATED FOR SINGAPORE GST PURPOSES (GST ACT SECTION 21(6) AND RECEIVED FOR USE AS STORES IN THE NAMED VESSEL, ON THE CONDITION THAT THE FUEL SHALL BE USED SOLELY BY MY VESSEL ON A VOYAGE TO OR FROM A DESTINATION OUTSIDE SINGAPORE

BARGE NAME & LICENCE NUMBER

NAME OF CARGO OFFICER

BARGE STAMP

SHIP'S STAMP & SIGNATURE OF MASTERS/CHIEF ENGINEER

DATE (DD MM YY)

TIME (24 HR)

WE DECLARE THE FUEL CHARACTERISTICS AND QUANTITY OF THE PRODUCTS SUPPLIED ARE CORRECT. THE FUEL OIL SUPPLIED IS IN CONFORMITY WITH REGULATIONS 14(1) OR 4(A) AND REGULATION 18(1) OF ANNEX VI TO M ARPOL 73/78.

SIGNATURE OF CARGO OFFICER

WAS A NOTE OF PROTEST ISSUED? YES ☐ NO ☐

THE FOLLOWING IS OUR SATISFACTION LEVEL OF THE BUNKERING OPERATION:

1 2 3 4 5

VERY UNSATISFIED VERY SATISFIED

BUNKER SUPPLIER LIC:

SUPPLYING FOR:

FIG. 11

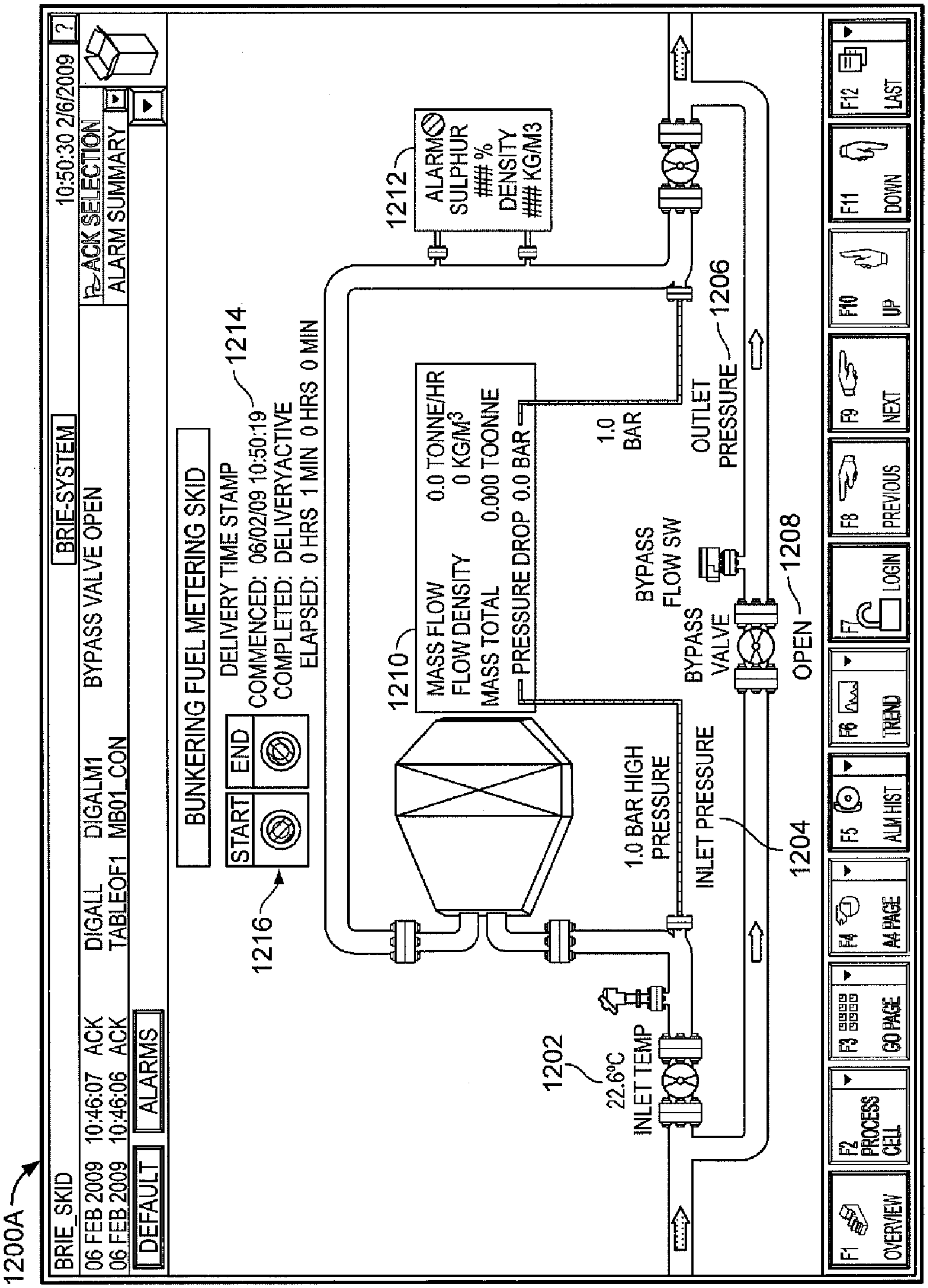

1200A
BRIE_SKID
BRIE-SYSTEM
10:50:30 2/6/2009
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
BUNKERING FUEL METERING SKID
1216
START
END
DELIVERY TIME STAMP
COMMENCED: 06/02/09 10:50:19
COMPLETED: DELIVERYACTIVE
ELAPSED: 0 HRS 1 MIN 0 HRS 0 MIN
1214
1210
MASS FLOW 0.0 TONNE/HR
FLOW DENSITY 0 KG/M3
MASS TOTAL 0.000 TOONNE
PRESSURE DROP 0.0 BAR
1212
ALARM
SULPHUR
%
DENSITY
KG/M3
1202
22.6°C
INLET TEMP
1.0 BAR HIGH PRESSURE
INLET PRESSURE
1204
BYPASS VALVE
OPEN
1208
BYPASS FLOW SW
1.0 BAR
OUTLET PRESSURE
1206
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 A4 PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 12A

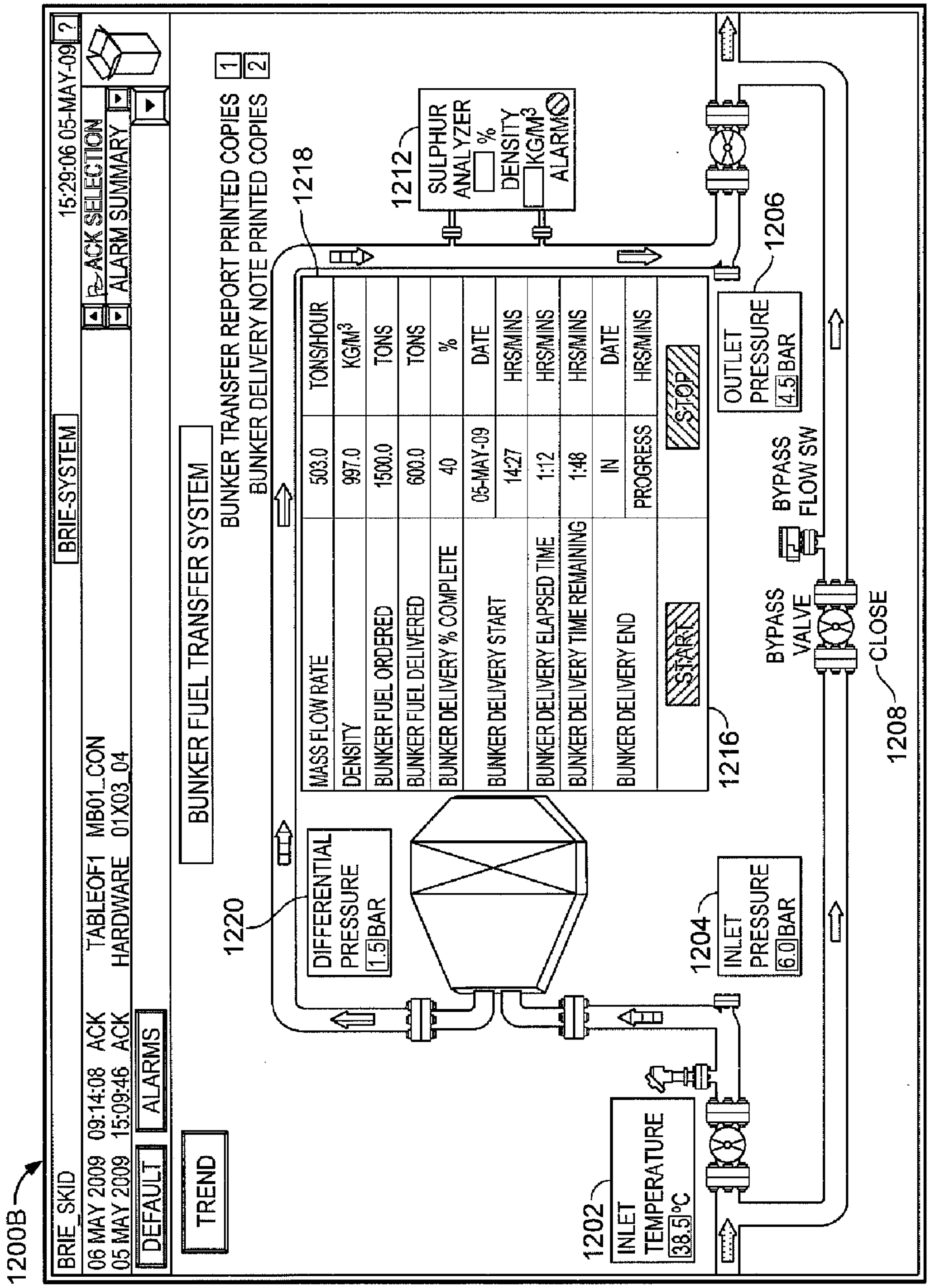

1200B
BRIE_SKID
BRIE-SYSTEM
15:29:06 05-MAY-09
06 MAY 2009 09:14:08 ACK TABLEOF1 MB01_CON
05 MAY 2009 15:09:46 ACK HARDWARE 01X03_04
ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
TREND
BUNKER FUEL TRANSFER SYSTEM
BUNKER TRANSFER REPORT PRINTED COPIES 1
BUNKER DELIVERY NOTE PRINTED COPIES 2
MASS FLOW RATE 503.0 TONS/HOUR
DENSITY 997.0 KG/M3
BUNKER FUEL ORDERED 1500.0 TONS
BUNKER FUEL DELIVERED 600.0 TONS
BUNKER DELIVERY % COMPLETE 40 %
BUNKER DELIVERY START 05-MAY-09 DATE
14:27 HRS/MINS
BUNKER DELIVERY ELAPSED TIME 1:12 HRS/MINS
BUNKER DELIVERY TIME REMAINING 1:48 HRS/MINS
BUNKER DELIVERY END IN DATE
PROGRESS HRS/MINS
START
STOP
1202
INLET TEMPERATURE 38.5 °C
1204
INLET PRESSURE 6.0 BAR
1220
DIFFERENTIAL PRESSURE 1.5 BAR
1216
1218
1212
SULPHUR ANALYZER %
DENSITY KG/M3
ALARM
1206
OUTLET PRESSURE 4.5 BAR
BYPASS FLOW SW
BYPASS VALVE
CLOSE
1208

FIG. 12B

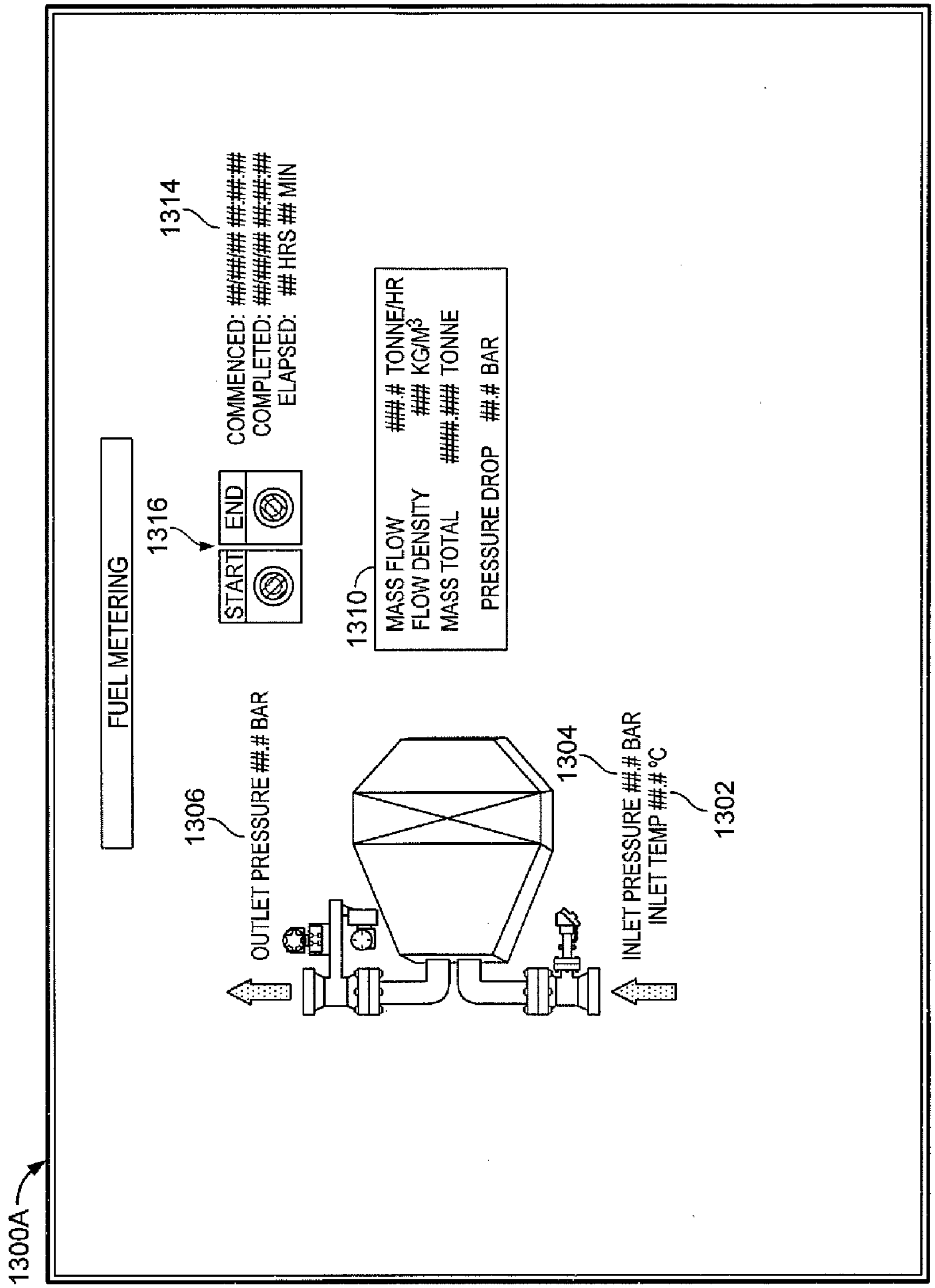

1300A
FUEL METERING
1316
START
END
1314
COMMENCED: ##/##/## ##:##:##
COMPLETED: ##/##/## ##:##:##
ELAPSED: ## HRS ## MIN
1310
MASS FLOW ###.# TONNE/HR
FLOW DENSITY ### KG/M3
MASS TOTAL ####.### TONNE
PRESSURE DROP ##.# BAR
1306
OUTLET PRESSURE ##.# BAR
1304
INLET PRESSURE ##.# BAR
INLET TEMP ##.# °C
1302

FIG. 13A

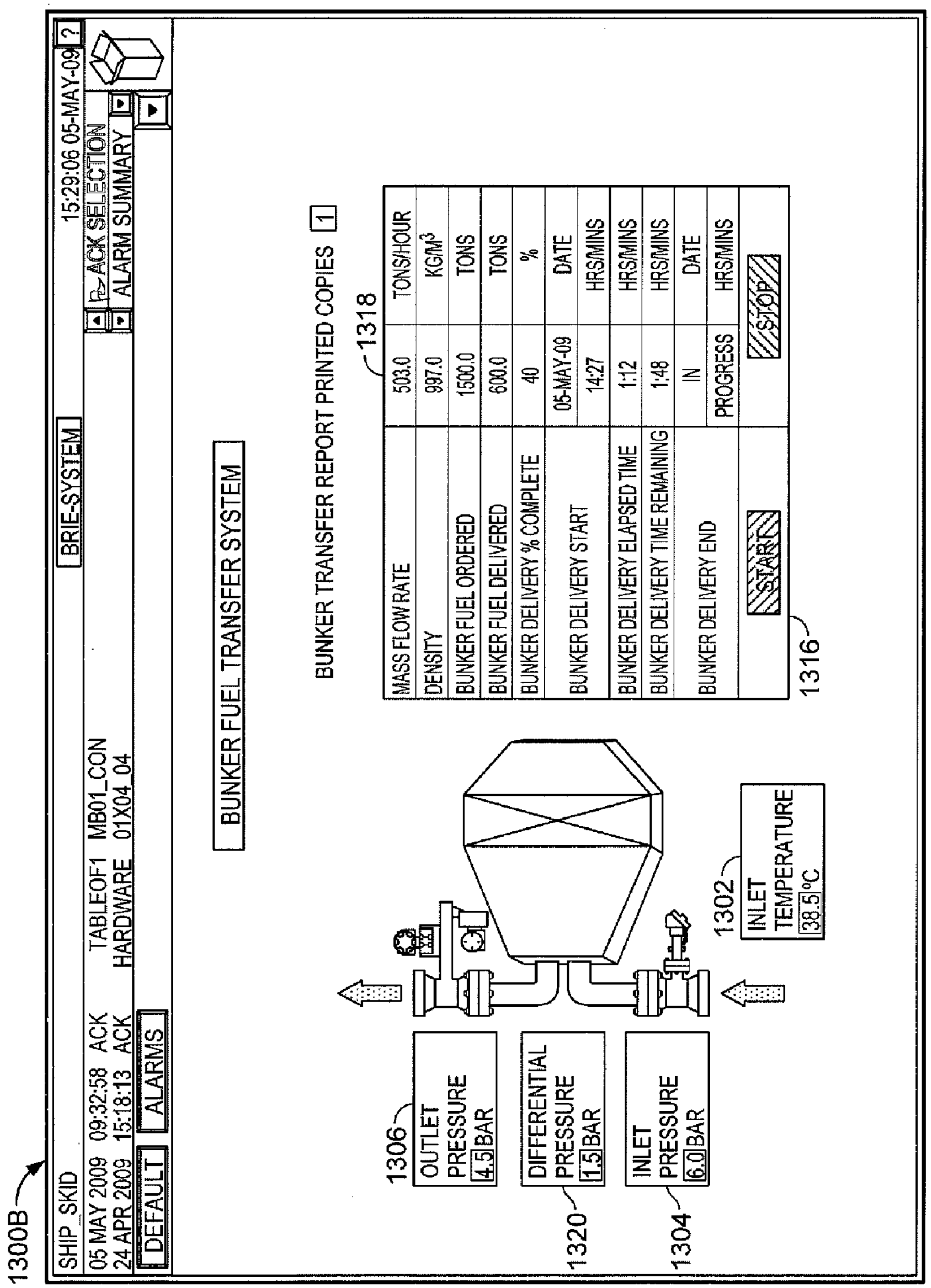

1300B
SHIP_SKID
BRIE-SYSTEM
15:29:06 05-MAY-09
?
05 MAY 2009 09:32:58 ACK TABLEOF1 MB01_CON
24 APR 2009 15:18:13 ACK HARDWARE 01X04_04
ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
BUNKER FUEL TRANSFER SYSTEM
BUNKER TRANSFER REPORT PRINTED COPIES 1
1318
MASS FLOW RATE 503.0 TONS/HOUR
DENSITY 997.0 KG/M3
BUNKER FUEL ORDERED 1500.0 TONS
BUNKER FUEL DELIVERED 600.0 TONS
BUNKER DELIVERY % COMPLETE 40 %
BUNKER DELIVERY START 05-MAY-09 DATE
14:27 HRS/MINS
BUNKER DELIVERY ELAPSED TIME 1:12 HRS/MINS
BUNKER DELIVERY TIME REMAINING 1:48 HRS/MINS
BUNKER DELIVERY END IN DATE
PROGRESS HRS/MINS
START
STOP
1316
1306
OUTLET PRESSURE 4.5 BAR
1320
DIFFERENTIAL PRESSURE 1.5 BAR
1304
INLET PRESSURE 6.0 BAR
1302
INLET TEMPERATURE 38.5 °C

FIG. 13B

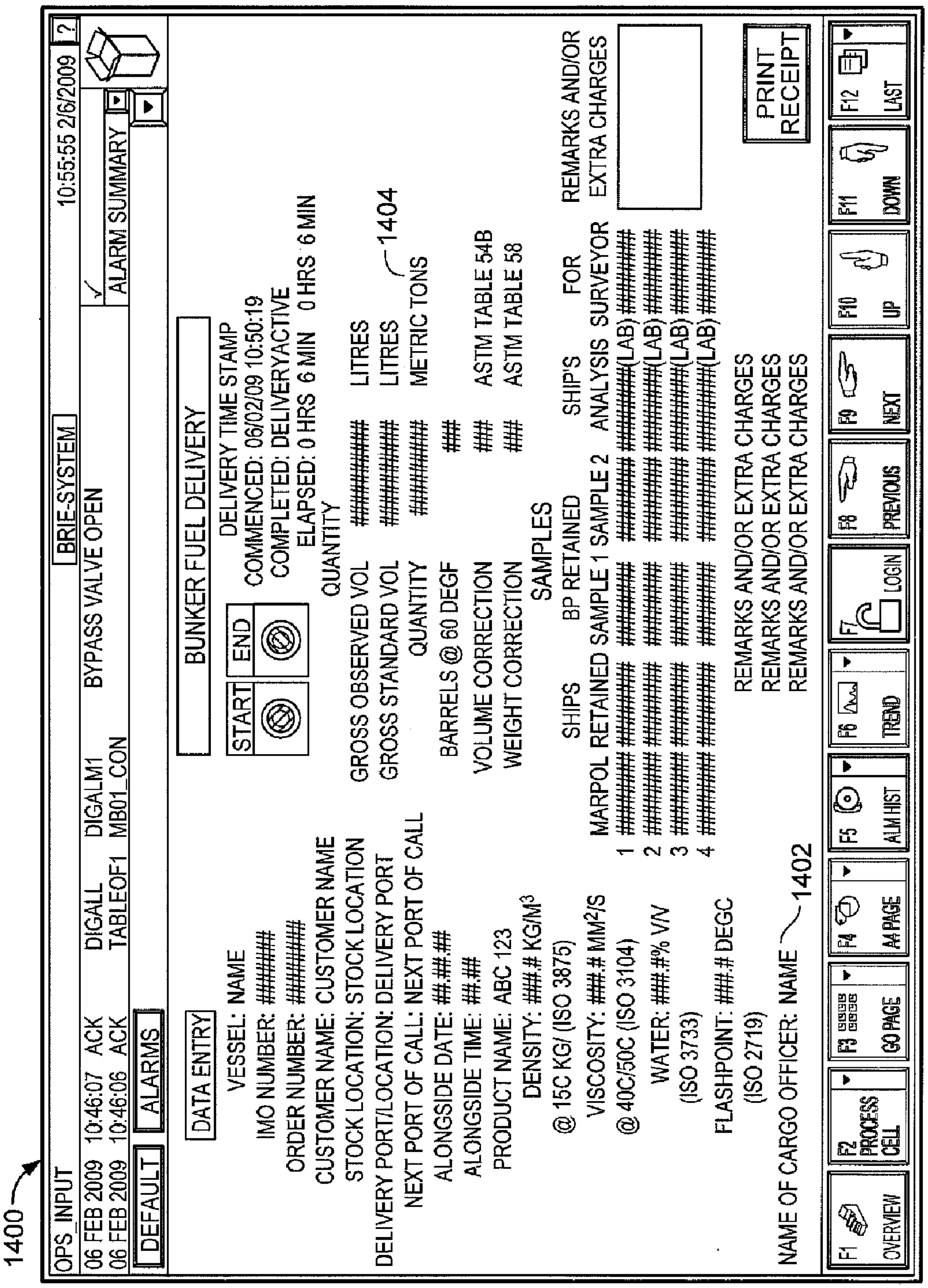

1400
OPS_INPUT
BRIE-SYSTEM
10:55:55 2/6/2009
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
DEFAULT
ALARMS
ALARM SUMMARY
DATA ENTRY
BUNKER FUEL DELIVERY
VESSEL: NAME
IMO NUMBER: #######
ORDER NUMBER: #######
CUSTOMER NAME: CUSTOMER NAME
STOCK LOCATION: STOCK LOCATION
DELIVERY PORT/LOCATION: DELIVERY PORT
NEXT PORT OF CALL: NEXT PORT OF CALL
ALONGSIDE DATE: ##.##.##
ALONGSIDE TIME: ##.##
PRODUCT NAME: ABC 123
DENSITY: ###.# KG/M3
@ 15C KG/ (ISO 3875)
VISCOSITY: ###.# MM2/S
@ 40C/50C (ISO 3104)
WATER: ###.#% V/V
(ISO 3733)
FLASHPOINT: ###.# DEGC
(ISO 2719)
NAME OF CARGO OFFICER: NAME
1402
START
END
DELIVERY TIME STAMP
COMMENCED: 06/02/09 10:50:19
COMPLETED: DELIVERYACTIVE
ELAPSED: 0 HRS 6 MIN 0 HRS 6 MIN
QUANTITY
GROSS OBSERVED VOL ######### LITRES
GROSS STANDARD VOL ######### LITRES
QUANTITY ######### METRIC TONS
1404
BARRELS @ 60 DEGF ###
VOLUME CORRECTION ### ASTM TABLE 54B
WEIGHT CORRECTION ### ASTM TABLE 58
SAMPLES
SHIPS MARPOL RETAINED
BP RETAINED SAMPLE 1 SAMPLE 2
SHIP'S ANALYSIS
FOR SURVEYOR
1 ####### ####### ####### ####### ########(LAB) ########
2 ####### ####### ####### ####### ########(LAB) ########
3 ####### ####### ####### ####### ########(LAB) ########
4 ####### ####### ####### ####### ########(LAB) ########
REMARKS AND/OR EXTRA CHARGES
REMARKS AND/OR EXTRA CHARGES
REMARKS AND/OR EXTRA CHARGES
REMARKS AND/OR EXTRA CHARGES
REMARKS AND/OR EXTRA CHARGES
REMARKS AND/OR EXTRA CHARGES
REMARKS AND/OR EXTRA CHARGES
PRINT RECEIPT
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 A4 PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 14

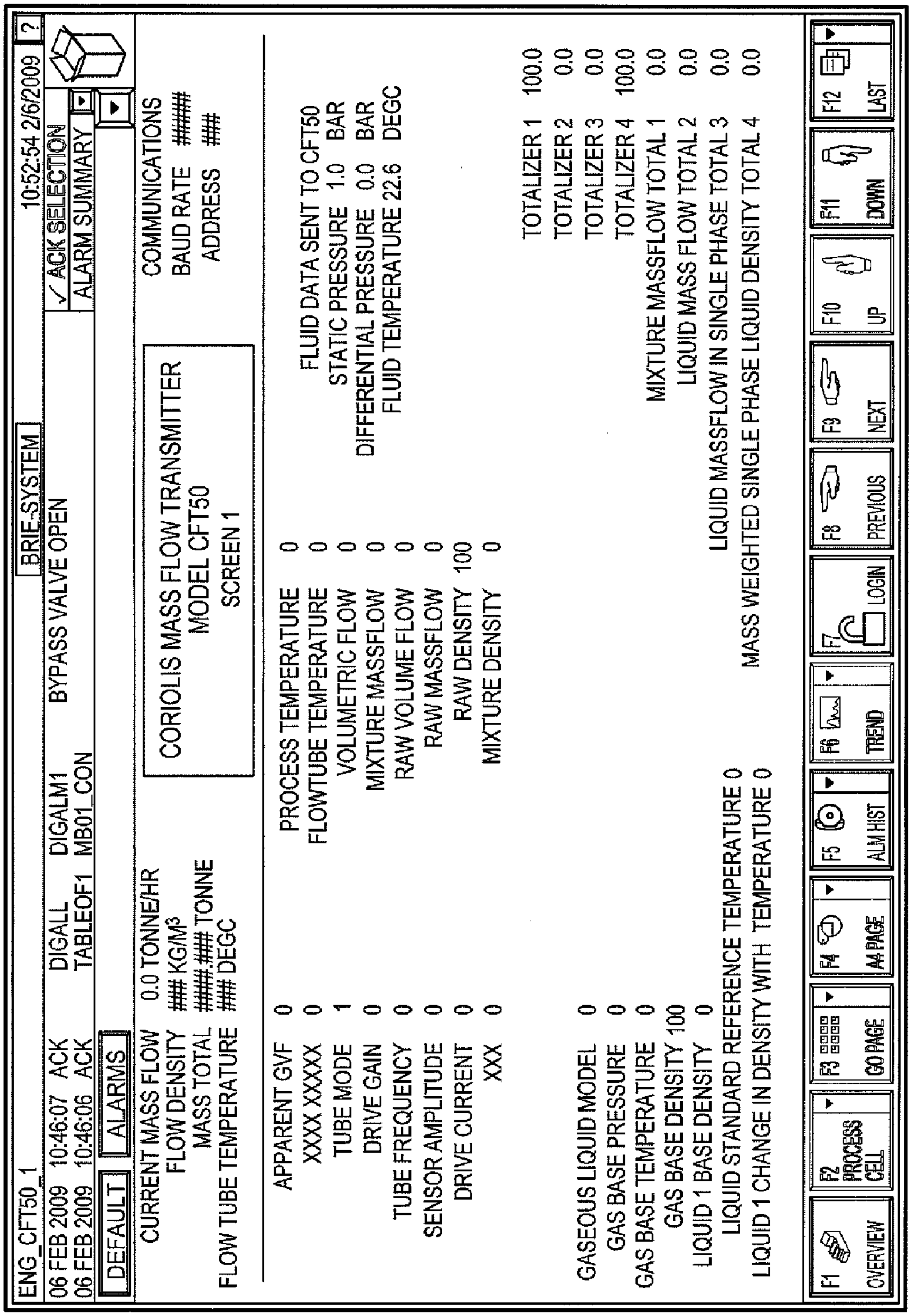

ENG_CFT50_1
BRIE-SYSTEM
10:52:54 2/6/2009
?
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
CURRENT MASS FLOW 0.0 TONNE/HR
FLOW DENSITY ### KG/M3
MASS TOTAL ####.### TONNE
FLOW TUBE TEMPERATURE ### DEGC
CORIOLIS MASS FLOW TRANSMITTER
MODEL CFT50
SCREEN 1
COMMUNICATIONS
BAUD RATE #####
ADDRESS ###
APPARENT GVF 0
XXXX XXXXX 0
TUBE MODE 1
DRIVE GAIN 0
TUBE FREQUENCY 0
SENSOR AMPLITUDE 0
DRIVE CURRENT 0
XXX 0
PROCESS TEMPERATURE 0
FLOWTUBE TEMPERATURE 0
VOLUMETRIC FLOW 0
MIXTURE MASSFLOW 0
RAW VOLUME FLOW 0
RAW MASSFLOW 0
RAW DENSITY 100
MIXTURE DENSITY 0
FLUID DATA SENT TO CFT50
STATIC PRESSURE 1.0 BAR
DIFFERENTIAL PRESSURE 0.0 BAR
FLUID TEMPERATURE 22.6 DEGC
GASEOUS LIQUID MODEL 0
GAS BASE PRESSURE 0
GAS BASE TEMPERATURE 0
GAS BASE DENSITY 100
LIQUID 1 BASE DENSITY 0
LIQUID STANDARD REFERENCE TEMPERATURE 0
LIQUID 1 CHANGE IN DENSITY WITH TEMPERATURE 0
TOTALIZER 1 100.0
TOTALIZER 2 0.0
TOTALIZER 3 0.0
TOTALIZER 4 100.0
MIXTURE MASSFLOW TOTAL 1 0.0
LIQUID MASS FLOW TOTAL 2 0.0
LIQUID MASSFLOW IN SINGLE PHASE TOTAL 3 0.0
MASS WEIGHTED SINGLE PHASE LIQUID DENSITY TOTAL 4 0.0
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 A4 PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 15

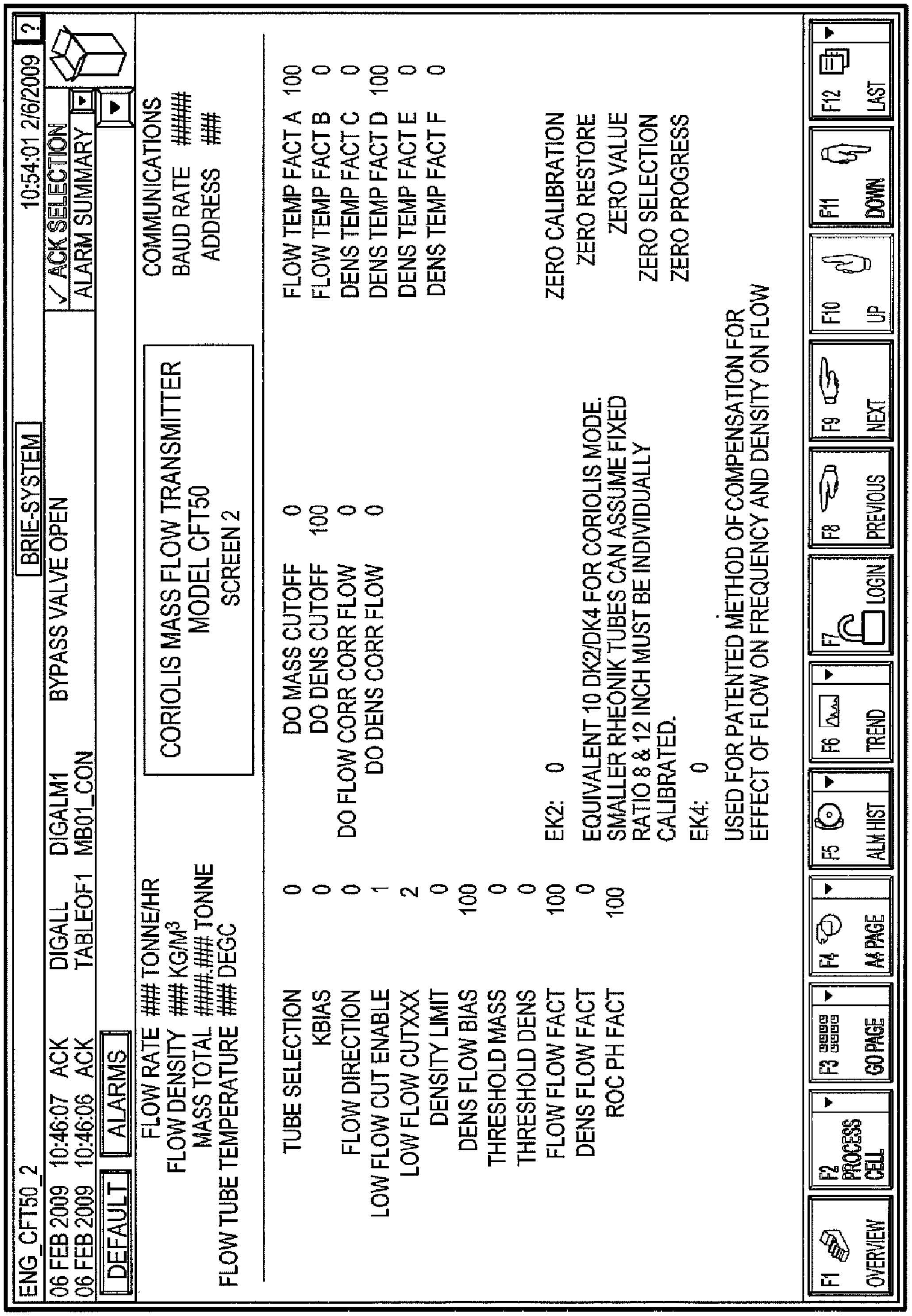

ENG_CFT50_2
BRIE-SYSTEM
10:54:01 2/6/2009
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
FLOW RATE ### TONNE/HR
FLOW DENSITY ### KG/M3
MASS TOTAL ####.### TONNE
FLOW TUBE TEMPERATURE ### DEGC
CORIOLIS MASS FLOW TRANSMITTER
MODEL CFT50
SCREEN 2
COMMUNICATIONS
BAUD RATE #####
ADDRESS ###
TUBE SELECTION 0
KBIAS 0
FLOW DIRECTION 0
LOW FLOW CUT ENABLE 1
LOW FLOW CUTXX 2
DENSITY LIMIT 0
DENS FLOW BIAS 100
THRESHOLD MASS 0
THRESHOLD DENS 0
FLOW FLOW FACT 100
DENS FLOW FACT 0
ROC PH FACT 100
DO MASS CUTOFF 0
DO DENS CUTOFF 100
DO FLOW CORR CORR FLOW 0
DO DENS CORR FLOW 0
FLOW TEMP FACT A 100
FLOW TEMP FACT B 0
DENS TEMP FACT C 0
DENS TEMP FACT D 100
DENS TEMP FACT E 0
DENS TEMP FACT F 0
EK2: 0
EQUIVALENT 10 DK2/DK4 FOR CORIOLIS MODE.
SMALLER RHEONIK TUBES CAN ASSUME FIXED
RATIO 8 & 12 INCH MUST BE INDIVIDUALLY
CALIBRATED.
EK4: 0
USED FOR PATENTED METHOD OF COMPENSATION FOR
EFFECT OF FLOW ON FREQUENCY AND DENSITY ON FLOW
ZERO CALIBRATION
ZERO RESTORE
ZERO VALUE
ZERO SELECTION
ZERO PROGRESS
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 AA PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 16

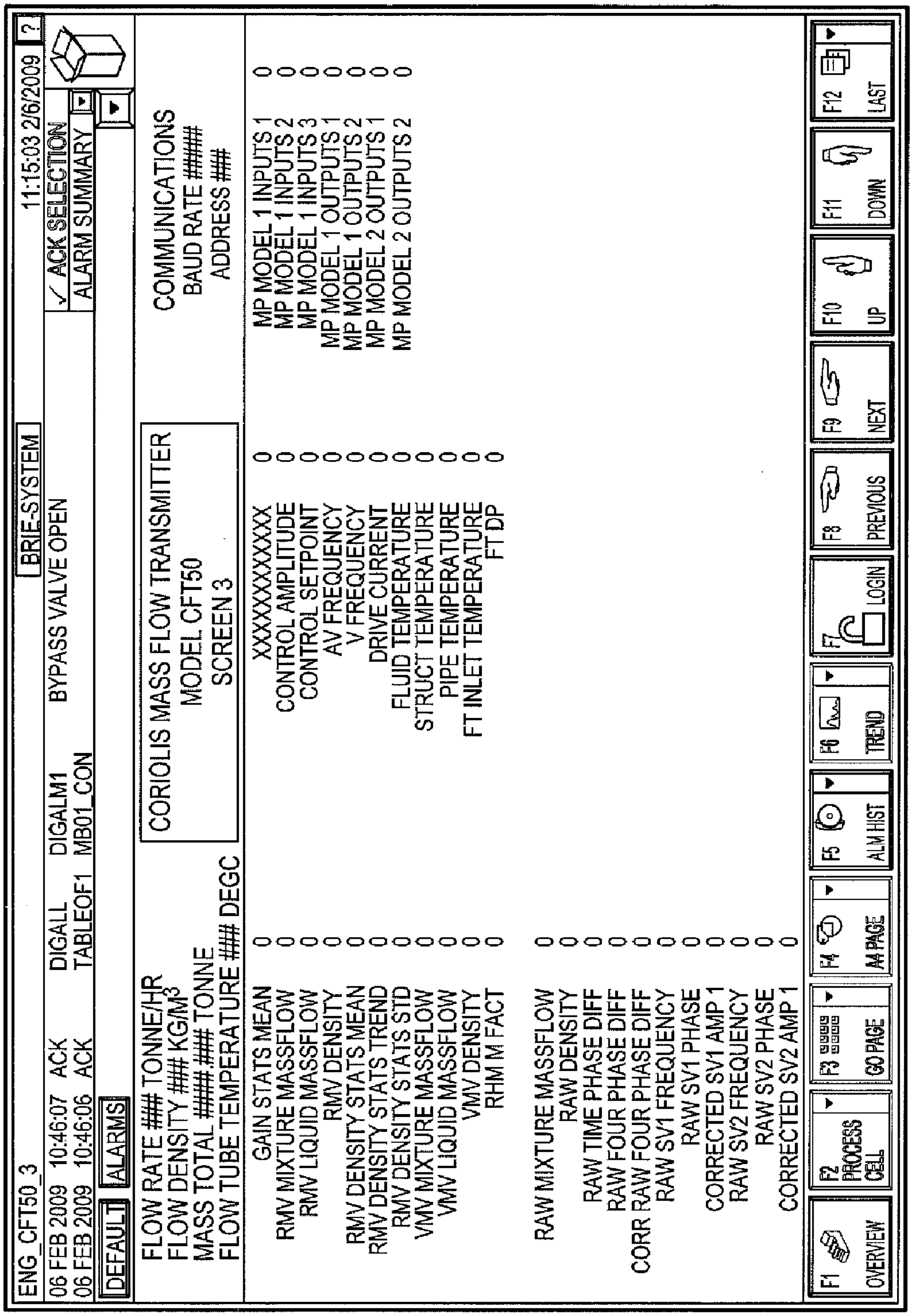

ENG_CFT50_3
BRIE-SYSTEM
11:15:03 2/6/2009
?
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
✓ ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
FLOW RATE ### TONNE/HR
FLOW DENSITY ### KG/M3
MASS TOTAL ####.### TONNE
FLOW TUBE TEMPERATURE ### DEGC
CORIOLIS MASS FLOW TRANSMITTER
MODEL CFT50
SCREEN 3
COMMUNICATIONS
BAUD RATE #####
ADDRESS ###
GAIN STATS MEAN 0
RMV MIXTURE MASSFLOW 0
RMV LIQUID MASSFLOW 0
RMV DENSITY 0
RMV DENSITY STATS MEAN 0
RMV DENSITY STATS TREND 0
RMV DENSITY STATS STD 0
VMV MIXTURE MASSFLOW 0
VMV LIQUID MASSFLOW 0
VMV DENSITY 0
RHM M FACT 0
RAW MIXTURE MASSFLOW 0
RAW DENSITY 0
RAW TIME PHASE DIFF 0
RAW FOUR PHASE DIFF 0
CORR RAW FOUR PHASE DIFF 0
RAW SV1 FREQUENCY 0
RAW SV1 PHASE 0
CORRECTED SV1 AMP 1 0
RAW SV2 FREQUENCY 0
RAW SV2 PHASE 0
CORRECTED SV2 AMP 1 0
XXXXXXXXXXXX 0
CONTROL AMPLITUDE 0
CONTROL SETPOINT 0
AV FREQUENCY 0
V FREQUENCY 0
DRIVE CURRENT 0
FLUID TEMPERATURE 0
STRUCT TEMPERATURE 0
PIPE TEMPERATURE 0
FT INLET TEMPERATURE 0
FT DP 0
MP MODEL 1 INPUTS 1 0
MP MODEL 1 INPUTS 2 0
MP MODEL 1 INPUTS 3 0
MP MODEL 1 OUTPUTS 1 0
MP MODEL 1 OUTPUTS 2 0
MP MODEL 2 OUTPUTS 1 0
MP MODEL 2 OUTPUTS 2 0
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 A4 PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 17

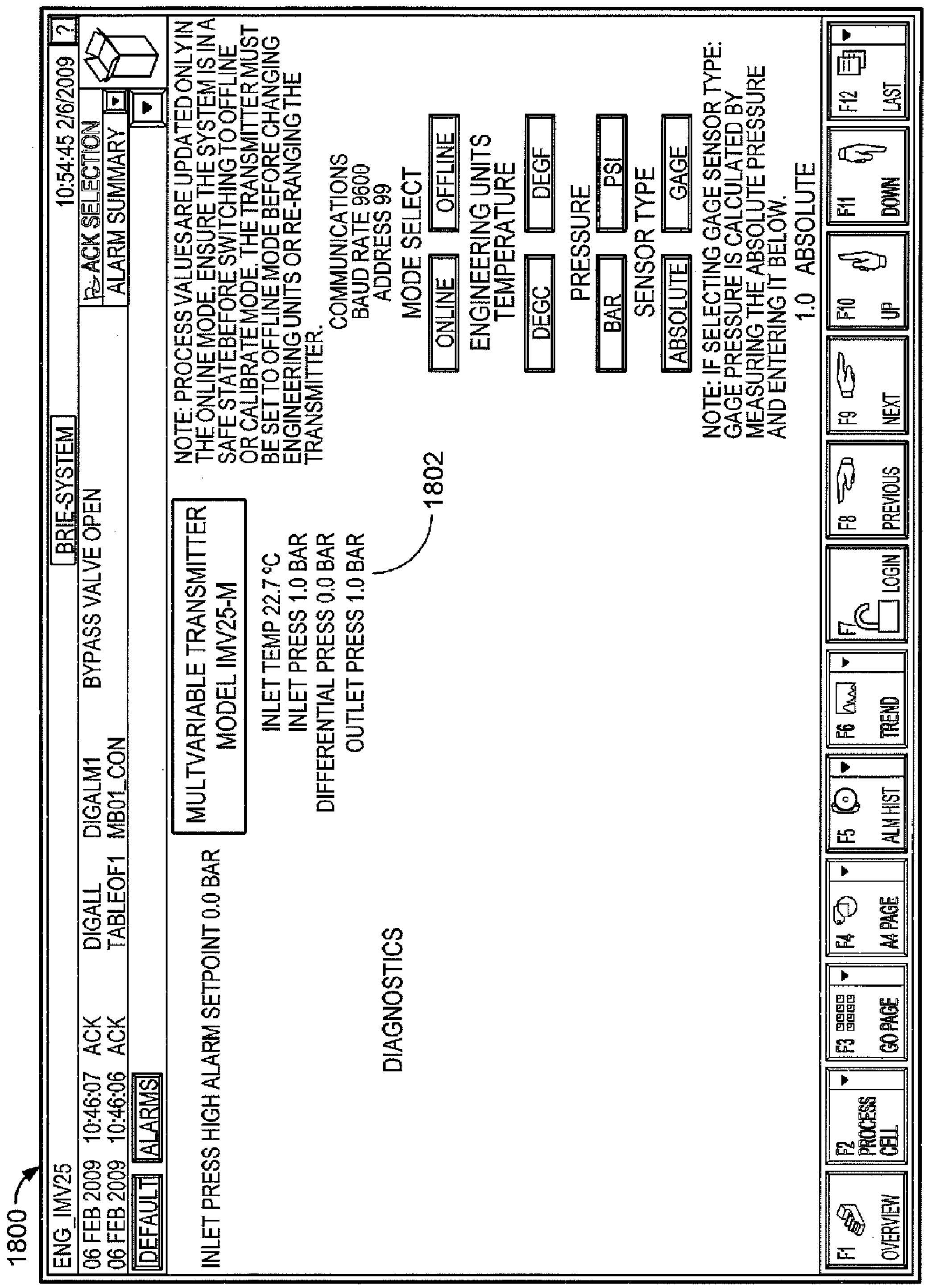

1800
ENG_IMV25
BRIE-SYSTEM
10:54:45 2/6/2009
?
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
ACK SELECTION
ALARM SUMMARY
DEFAULT
ALARMS
INLET PRESS HIGH ALARM SETPOINT 0.0 BAR
MULTVARIABLE TRANSMITTER
MODEL IMV25-M
INLET TEMP 22.7 °C
INLET PRESS 1.0 BAR
DIFFERENTIAL PRESS 0.0 BAR
OUTLET PRESS 1.0 BAR
1802
DIAGNOSTICS
NOTE: PROCESS VALUES ARE UPDATED ONLY IN THE ONLINE MODE. ENSURE THE SYSTEM IS IN A SAFE STATE BEFORE SWITCHING TO OFFLINE OR CALIBRATE MODE. THE TRANSMITTER MUST BE SET TO OFFLINE MODE BEFORE CHANGING ENGINEERING UNITS OR RE-RANGING THE TRANSMITTER.
COMMUNICATIONS
BAUD RATE 9600
ADDRESS 99
MODE SELECT
ONLINE
OFFLINE
ENGINEERING UNITS
TEMPERATURE
DEGC
DEGF
PRESSURE
BAR
PSI
SENSOR TYPE
ABSOLUTE
GAGE
NOTE: IF SELECTING GAGE SENSOR TYPE: GAGE PRESSURE IS CALCULATED BY MEASURING THE ABSOLUTE PRESSURE AND ENTERING IT BELOW.
1.0 ABSOLUTE
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 A4 PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 18

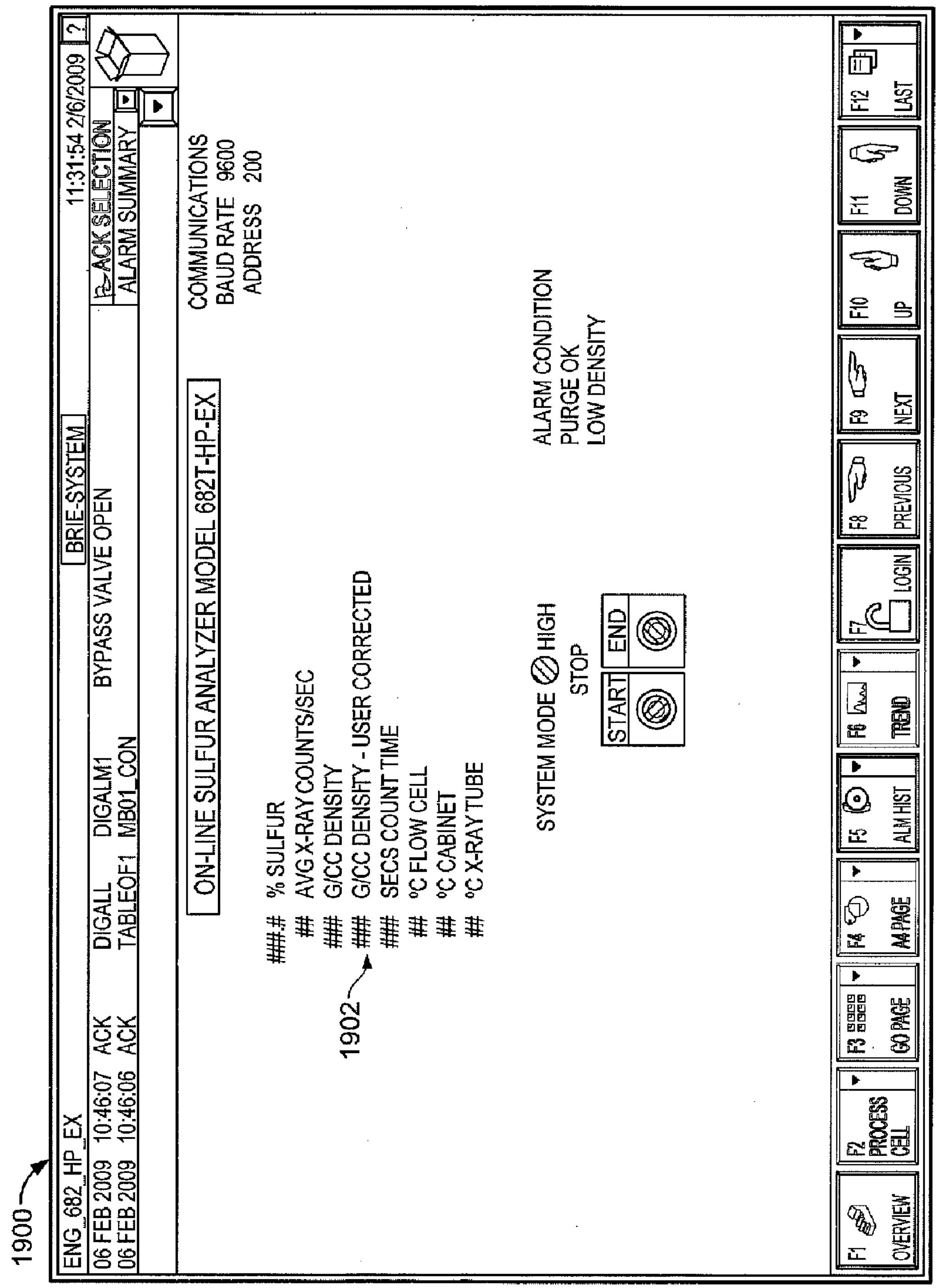

1900
ENG_682_HP_EX
BRIE-SYSTEM
11:31:54 2/6/2009
?
06 FEB 2009 10:46:07 ACK DIGALL DIGALM1 BYPASS VALVE OPEN
06 FEB 2009 10:46:06 ACK TABLEOF1 MB01_CON
ACK SELECTION
ALARM SUMMARY
ON-LINE SULFUR ANALYZER MODEL 682T-HP-EX
COMMUNICATIONS
BAUD RATE 9600
ADDRESS 200
###.# % SULFUR
AVG X-RAY COUNTS/SEC
G/CC DENSITY
G/CC DENSITY - USER CORRECTED
SECS COUNT TIME
°C FLOW CELL
°C CABINET
°C X-RAY TUBE
1902
SYSTEM MODE HIGH
STOP
START
END
ALARM CONDITION
PURGE OK
LOW DENSITY
F1 OVERVIEW
F2 PROCESS CELL
F3 GO PAGE
F4 AM PAGE
F5 ALM HIST
F6 TREND
F7 LOGIN
F8 PREVIOUS
F9 NEXT
F10 UP
F11 DOWN
F12 LAST

FIG. 19

BUNKER FUEL TRANSFER

CLAIM OF PRIORITY

[0001] This application claims priority under 35 USC §119 (e) to U.S. Patent Application Ser. No. 61/155,883, filed on Feb. 26, 2009 and U.S. Patent Application Ser. No. 61/181,963, filed on May 28, 2009. The entire contents of both are incorporated by reference.

TECHNICAL FIELD

[0002] This description relates to the transfer of bunker fuels.

BACKGROUND

[0003] Bunker fuel generally refers to any type of fuel oil used aboard ships. Bunker fuels are delivered to commercial ships via bunker barges, which often hold the bunker fuel in large tanks. The practice of delivering bunker fuels is commonly referred to as "bunkering", as such bunker barges can also be known as bunkering barges. The bunker fuel is typically pumped from the barge's tanks to the commercial ships. At times, bunker fuels may be transferred between bunker barges. A bunker barge owner/operator typically time charters the operation of the bunker barge to a major oil supplier, where the contracted bunker barge service is used by the oil supplier to deliver marine fuels to ships. The term "stem" is used to refer to the fuel delivered during a particular bunker delivery. For example, a ship might receive a 500 ton stem.

SUMMARY

[0004] In one aspect, a bunker fuel transfer system includes a Coriolis flowmeter, at least one sensor, and a computing system. The Coriolis flowmeter has a flowtube with an inlet that is configured to be coupled to a first conduit that provides bunker fuel from a bunker barge and an outlet that is configured to be coupled to a second conduit that provides the bunker fuel to a receiving vessel. The Coriolis flowmeter is configured to measure a flowrate of the bunker fuel as the bunker fuel flows through the flowtube. The sensor is configured to measure a parameter of the bunker fuel as the bunker fuel flows through the flowtube. The computing system is configured to receive the measured flowrate from the Coriolis flowmeter, receive the measured parameter from the sensor, and generate a bunker transfer report based on the received flowrate and the received parameter. The bunker transfer report includes a total amount of the bunker fuel that is transferred from the bunker barge to the receiving vessel and information related to the parameter measured by the sensor.

[0005] Implementations may include one or more of the following features. The bunker transfer report may include one or more graphs displaying the measured flowrate of the bunker fuel over time and the measured parameter over time. The bunker transfer report may include one or more graphs displaying the total amount of bunker fuel transferred over time.

[0006] The Coriolis flowmeter may be configured to measure a mixture density of the bunker fuel with entrained air as the bunker fuel flows through the flowtube. The bunker transfer report may include information related to the mixture density, such as one or more graphs displaying the mixture density over time.

[0007] The Coriolis flowmeter may be configured to detect when air is entrained in the bunker fuel as the bunker fuel flows through the flowtube. The bunker transfer report may include information related to the air entrained in the bunker fuel as the bunker fuel flows through the flowtube.

[0008] The bunker transfer report may include information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube. The system may include one or more of a viscometer configured to measure a viscosity of the bunker fuel as the bunker fuel flows through the flowtube, a water cut meter configured to measure a water content of the bunker fuel as the bunker fuel flows through the flowtube, or a sulphur analyzer configured to measure a sulphur content of the bunker fuel as the bunker fuel flows through the flowtube. The information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube may include information related to the viscosity of the bunker fuel measured by the viscometer, information related to the water content of the bunker fuel measured by the water cut meter, or information related to the sulphur content of the bunker fuel measured by the sulphur analyzer.

[0009] The at least one sensor may include a temperature sensor and the parameter may be a temperature at the inlet of the flowtube. The at least one sensor may be a pressure sensor and the parameter may be a pressure at the inlet or outlet of the flowtube. The at least one sensor may include two pressures sensors and the parameter may be a differential pressure between the inlet and outlet of the flowtube.

[0010] The system may include multi-variable transmitter configured to transfer the measured parameter from the at least one sensor to the computing system. The computing device may be configured to display information related to the flowrate and the measured parameter on a display device.

[0011] In another aspect, an inlet of a flowtube of a Coriolis flowmeter is coupled to a first conduit that provides bunker fuel from a bunker barge. An outlet of the flowtube is coupled to a second conduit that provides the bunker fuel to a receiving vessel. A flowrate of the bunker fuel is measured using the Coriolis flowmeter as the bunker fuel flows through the flowtube. A parameter of the bunker fuel is measured using at least one sensor as the bunker fuel flows through the flowtube. A bunker transfer report is generated based on the measured flowrate and the measured parameter. The bunker transfer report includes a total amount of the bunker fuel that is transferred from the bunker barge to the receiving vessel and information related to the parameter measured by the sensor.

[0012] Implementations of this aspect may include one or more the following features.

[0013] The bunker transfer report may include one or more graphs displaying the measured flowrate of the bunker fuel over time and the measured parameter over time. The bunker transfer report may include one or more graphs displaying the total amount of bunker fuel transferred over time.

[0014] A mixture density of the bunker fuel with entrained air may be measured using the Coriolis flowmeter as the bunker fuel flows through the flowtube. The bunker transfer report may include information related to the mixture density, such as one or more graphs displaying the mixture density over time.

[0015] The Coriolis flowmeter may be used to detect when air is entrained in the bunker fuel as the bunker fuel flows through the flowtube. The bunker transfer report may include information related to the air entrained in the bunker fuel as the bunker fuel flows through the flowtube.

[0016] The bunker transfer report may include information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube. A viscosity of the bunker fuel as the bunker fuel flows through the flowtube may be measured, a water content of the bunker fuel as the bunker fuel flows through the flowtube may be measured, or a sulphur content of the bunker fuel as the bunker fuel flows through the flowtube may be measured. The information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube may include information related to the measured viscosity of the bunker fuel, information related to the measured water content of the bunker fuel, or information related to the measured sulphur content of the bunker fuel.

[0017] The at least one sensor may include a temperature sensor and the parameter may be a temperature at the inlet of the flowtube. The at least one sensor may be a pressure sensor and the parameter may be a pressure at the inlet or outlet of the flowtube. The at least one sensor may include two pressures sensors and the parameter may be a differential pressure between the inlet and outlet of the flowtube.

[0018] The measured parameter may be transmitted from the at least one sensor to a computing system using a multi-variable transmitter. Information related to the flowrate and the measured parameter may be displayed on a display device.

[0019] Implementations of any of the techniques described above may include a method or process, a system, or instructions stored on a storage device. The details of particular implementations are set forth in the accompanying drawings and description below. Other features will be apparent from the following description, including the drawings, and the claims.

DESCRIPTION OF DRAWINGS

[0020] FIG. **1**A is an illustration of a Coriolis flowmeter using a bent flowtube.

[0021] FIG. **1**B is an illustration of a Coriolis flowmeter using a straight flowtube.

[0022] FIG. **2** is a block diagram of a Coriolis flowmeter.

[0023] FIG. **3** depicts a block diagram of an example of a multi-measurement metering system installed on a skid and a BRIE system installed in a vessel control room.

[0024] FIGS. **4** and **5** illustrate an example of a multi-measurement metering system installed on a skid.

[0025] FIG. **6** illustrates an example of the skid installed on the deck of a bunker barge.

[0026] FIG. **7** illustrates an example of a BRIE system.

[0027] FIGS. **8**A and **8**B illustrate an example of a simplified multi-measurement metering system.

[0028] FIGS. **9**A-**9**C show an example of a bunker transfer report.

[0029] FIGS. **10**A-**10**C show an example of an alternative bunker transfer report.

[0030] FIG. **11** shows an example of a bunker delivery note that may be generated by a BRIE system.

[0031] FIGS. **12**-**19** show examples of screens that may be displayed by a BRIE system to allow for real-time monitoring of a bunker fuel transfer.

DETAILED DESCRIPTION

[0032] Overview

[0033] The following describes implementations of a bunker fuel transfer system that includes a multi-measurement metering system and bunkering receipt issuing equipment (BRIE). The bunker fuel transfer system can be installed on either the bunker barge or the ship receiving the bunker fuel. Various implementations can provide for quantity certainty of bunker fuel delivery transactions, and can provide for automated bunker fuel transfer reports. The bunker fuel transfer reports can include details and trends of the bunker fuel transfers to allow for quantity measurement validation. In addition, some implementations may provide for quality validation by including pertinent measurements, which can be included in the reports.

[0034] In one implementation, the multi-measurement metering system includes a Coriolis flowmeter, a temperature sensor, pressure sensors, and a multi-variable transmitter. The bunker fuel is pumped through the Coriolis flowmeter during the transfer, and the Coriolis flowmeter measures the mass flowrate of the liquid (e.g., bunker fuel), the mixture density (e.g., combined bunker fuel and air when entrained air is present or solely bunker fuel when entrained air is not present) the total mass of the transfer, and other parameters such as, for example, parameters related to the gas void fraction present in the fuel. The temperature sensor measures the fluid temperature of the bunker fuel at the inlet of the metering system. The pressure sensors sense the fluid pressure at the inlet of the metering system and the pressure drop between the inlet and the outlet of the metering system.

[0035] The Coriolis flowmeter transfers the mass flowrate, density, total mass and other measurements to the BRIE. Also, the multi-variable transmitter transmits the temperature and pressure measurements to the BRIE. The BRIE then generates a bunker report that includes the total mass transferred, as well as information regarding the other measured parameters. For example, the report can include the mass weighted averages of the mixture density, the fluid temperature, and the inlet fluid pressure throughout the transfer. The report can also include graphs of one or more of the liquid mass flowrate, the mixture density, the cumulative liquid mass flow total, the fluid temperature, the inlet fluid pressure, and the pressure drop during the transfer.

[0036] The information regarding the other measured parameters can be used to validate the reported total mass transferred by providing insight into various conditions of the bunker fuel during the transfer that affect the mass transferred. For instance, fluctuations in the mixture density result in fluctuations of the liquid mass flowrate. The mixture density may fluctuate as a result of a fluctuation in the temperature of the bunker fuel, as a result of entrained air, or a combination of both. In addition, increases in pressure increase the mass flowrate, while decreases in pressure decrease the mass flowrate. Thus, fluctuations of the mass flow rate during the transfer can be validated as legitimate fluctuations, for example, by noting corresponding fluctuations in the mixture density, temperature, and/or pressure. Including information regarding the mass flow rate, the bulk density, fluid pressure, and fluid temperature, or some combination thereof, in the report may allow a viewer of the report to understand the various conditions of the bunker fuel during transfer, which can validate the reported total mass transferred.

[0037] In addition, in various implementations, the information regarding the other measured parameters can be used to validate the quality of the bunker fuel. For instance, the fuel density at a reference density and pressure can be determined to assess whether it is within established standards. Some implementations also can include additional measurements for quality, such as a sulphur content and/or viscosity.

[0038] In various implementations, the Coriolis flowmeter also may provide an indication of when the bunker fuel contains entrained air, and the bunker transaction reports can also indicate the amount of bunker fuel during the batch that contained entrained gas. Also, in various implementations, the BRIE can provide a human-machine-interface (HMI) that shows real-time information regarding the transfer, such as the liquid mass flowrate, the mixture density, the cumulative liquid mass flow total, the fluid temperature, the fluid pressure, and the pressure drop.

[0039] Coriolis Flowmeters

[0040] Coriolis-type mass flowmeters are based on the Coriolis effect, in which material flowing through a conduit becomes a radially-travelling mass that is affected by a Coriolis force and therefore experiences an acceleration. Many Coriolis-type mass flowmeters induce a Coriolis force by sinusoidally oscillating a conduit about a pivot axis orthogonal to the length of the conduit. In such mass flowmeters, the Coriolis reaction force experienced by the traveling fluid mass is transferred to the conduit itself and is manifested as a deflection or offset of the conduit in the direction of the Coriolis force vector in the plane of rotation.

[0041] Types of flowmeters include digital Coriolis flowmeters. For example, U.S. Pat. No. 6,311,136, which is hereby incorporated by reference, discloses the use of a digital Coriolis flowmeter and related technology including signal processing and measurement techniques. Such digital flowmeters may be very precise in their measurements, with little or negligible noise, and may be capable of enabling a wide range of positive and negative gains at the driver circuitry for driving the conduit. Such digital Coriolis flowmeters are thus advantageous in a variety of settings. For example, commonly-assigned U.S. Pat. No. 6,505,519, which is incorporated by reference, discloses the use of a wide gain range, and/or the use of negative gain, to prevent stalling and to more accurately exercise control of the flowtube, even during difficult conditions such as two-phase flow (e.g., a flow containing a mixture of liquid and gas). Additionally, commonly-assigned U.S. Pat. No. 7,480,576, which is incorporated by reference, discloses various methods for processing signals representing modes of vibration of the flowtube to determine one or more properties of the fluid flowing through the flowmeter. The disclosed processing methods may be particularly useful in flowmeter applications (e.g. bunkering) using large curved mass flowtubes to compensate for the effects of frequency change.

[0042] Although digital Coriolis flowmeters are specifically discussed below with respect to, for example, FIGS. **1**A, **1**B and **2**, it should be understood that analog Coriolis flowmeters also exist. Although such analog Coriolis flowmeters may be prone to typical shortcomings of analog circuitry, e.g., low precision and high noise measurements relative to digital Coriolis flowmeters, they also may be compatible with the various techniques and implementations discussed herein. Thus, in the following discussion, the term "Coriolis flowmeter" or "Coriolis meter" is used to refer to any type of device and/or system in which the Coriolis effect is used to measure a mass flowrate, density, and/or other parameters of a material(s) moving through a flowtube or other conduit.

[0043] FIG. **1**A is an illustration of a digital Coriolis flowmeter using a bent flowtube **102**. Specifically, the bent flowtube **102** may be used to measure one or more physical characteristics of, for example, a (traveling or non-traveling) fluid, as referred to above. In FIG. **1**A, a digital transmitter **104** exchanges sensor and drive signals with the bent flowtube **102**, so as to both sense an oscillation of the bent flowtube **102**, and to drive the oscillation of the bent flowtube **102** accordingly. By quickly and accurately determining the sensor and drive signals, the digital transmitter **104**, as referred to above, may provide for fast and accurate operation of the bent flowtube **102**. Examples of the digital transmitter **104** being used with a bent flowtube are provided in, for example, commonly-assigned U.S. Pat. No. 6,311,136.

[0044] FIG. **1**B is an illustration of a digital Coriolis flowmeter using a straight flowtube **106**. More specifically, in FIG. **1**B, the straight flowtube **106** interacts with the digital transmitter **104**. Such a straight flowtube operates similarly to the bent flowtube **102** on a conceptual level, and has various advantages/disadvantages relative to the bent flowtube **102**. For example, the straight flowtube **106** may be easier to (completely) fill and empty than the bent flowtube **102**, simply due to the geometry of its construction. In operation, the bent flowtube **102** may operate at a frequency of, for example, 50-110 Hz, while the straight flowtube **106** may operate at a frequency of, for example, 300-1,000 Hz. The bent flowtube **102** represents flowtubes having a variety of diameters, and may be operated in multiple orientations, such as, for example, in a vertical or horizontal orientation. The straight flowtube **106** also may have a variety of diameters, and may be operated in multiple orientations.

[0045] Referring to FIG. **2**, a digital mass flowmeter **200** includes the digital transmitter **104**, one or more motion sensors **205**, one or more drivers **210**, a flowtube **215** (which also may be referred to as a conduit, and which may represent either the bent flowtube **102**, the straight flowtube **106**, or some other type of flowtube), a temperature sensor **220**, and a pressure sensor **225**. The digital transmitter **104** may be implemented using one or more of, for example, a processor, a Digital Signal Processor (DSP), a field-programmable gate array (FPGA), an ASIC, other programmable logic or gate arrays, or programmable logic with a processor core. It should be understood that, as described in U.S. Pat. No. 6,311,136, associated digital-to-analog converters may be included for operation of the drivers **210**, while analog-to-digital converters may be used to convert sensor signals from the sensors **205** for use by the digital transmitter **104**.

[0046] The digital transmitter **104** may include a bulk density measurement system **240** and a bulk mass flowrate measurement system **250**. Bulk properties generally refer to properties of the fluid as a whole, as opposed to the properties of a constituent component of the fluid when multi-phase flow is present (as described below). Density measurement system **240** and mass flowrate measurement system **250** may generate measurements of, respectively, density and/or mass flowrate of a material flowing through the flowtube **215** based at least on signals received from the motion sensors **205**. The digital transmitter **104** also controls the drivers **210** to induce motion in the flowtube **215**. This motion is sensed by the motion sensors **205**.

[0047] Density measurements of the material flowing through the flowtube are related to, for example, the frequency of the motion of the flowtube **215** that is induced in the flowtube **215** (typically the resonant frequency) by a driving force supplied by the drivers **210**, and/or to the temperature of the flowtube **215**. Similarly, mass flow through the flowtube **215** is related to the phase and frequency of the motion of the flowtube **215**, as well as to the temperature of the flowtube **215**.

[0048] The temperature in the flowtube **215**, which is measured using the temperature sensor **220**, affects certain properties of the flowtube, such as its stiffness and dimensions. The digital transmitter **104** may compensate for these temperature effects. Also in FIG. **2**, a pressure sensor **225** is in communication with the transmitter **104**, and is connected to the flowtube **215** so as to be operable to sense a pressure of a material flowing through the flowtube **215**.

[0049] It should be understood that both the pressure of the fluid entering the flowtube **215** and the pressure drop across relevant points on the flowtube may be indicators of certain flow conditions. Also, while external temperature sensors may be used to measure the fluid temperature, such sensors may be used in addition to an internal flowmeter sensor designed to measure a representative temperature for flowtube calibrations. Also, some flowtubes use multiple temperature sensors for the purpose of correcting measurements for an effect of differential temperature between the process fluid and the environment (e.g., a case temperature of a housing of the flowtube).

[0050] In FIG. **2**, it should be understood that the various components of the digital transmitter **104** are in communication with one another, although communication links are not explicitly illustrated, for the sake of clarity. Further, it should be understood that conventional components of the digital transmitter **104** are not illustrated in FIG. **2**, but are assumed to exist within, or be accessible to, the digital transmitter **104**. For example, the digital transmitter **104** will typically include drive circuitry for driving the driver **210**, and measurement circuitry to measure the oscillation frequency of the flowtube **215** based on sensor signals from sensors **205** and to measure the phase between the sensor signals from sensors **205**.

[0051] Under certain conditions, a Coriolis flowmeter can accurately determine the bulk (mixture) density and bulk (mixture) mass flowrate of a process fluid in the flowtube **215**. That is, an accurate bulk density and/or bulk mass flowrate of the process fluid can be determined under certain conditions.

[0052] Also, in some situations, the process fluid may contain more than one phase by being a mixture of two or more materials (for example, oil and water or a fluid with entrained gas), by being the same material in different phases (for example, liquid water and water vapor), or by being different materials in different phases (for example, water vapor and oil). In some multi-phase flow conditions, a Coriolis flowmeter may accurately determine the bulk density and bulk mass flowrate of the fluid, which can then be used to accurately determine the density and/or mass flowrate of the constituent phases. For example, U.S. Pat. Nos. 6,311,136; 6,505,519; and 7,059,199 describe various techniques for handling multi-phase flows, and accurately determining parameters such as the bulk density, the bulk mass flowrate, densities of the constituent phases, and the mass flowrates of the constituent phases.

[0053] Bunker Fuel Transfer System

[0054] Referring to FIG. **3**, one implementation of a bunker fuel transfer system **300** includes a multi-measurement metering system installed on a skid **310** and a BRIE system installed in a vessel control room **320**.

[0055] The skid **310** can be configured to be installed on the deck of a bunker barge in the hazardous area. Installed on the skid **310** are a Coriolis flowtube **310***a* (e.g., a model CSF40 available from Invensys Process Systems of Plano, Tex.), a Coriolis transmitter **310***b* (e.g., a model CFT50 available from Invensys Process Systems of Plano, Tex.), a multi-variable transmitter **310***c* coupled to a resistance temperature detector **310***d* (RTD), and a sulphur analyzer **310***e*. The Coriolis flowtube **310***a* is coupled to piping that causes the bunker fluid to flow through the Coriolis flowtube **310***a* during transfer so that the Coriolis transmitter **310***b* can determine the liquid mass flowrate and the mixture density. For example, the flowtube may include an inlet that is coupled to a first conduit that provides bunker fuel from the bunker barge and an outlet that is coupled to a second conduit that provides the bunker fuel to the receiving vessel. The multi-variable transmitter **310***c* and RTD **310***d* are coupled to the piping so as to obtain fluid temperature measurements at the inlet of the skid **310**, fluid pressure measurements at the inlet of the skid **310**, and the fluid pressure differential between the inlet and outlet of the skid **310**. The sulphur analyzer **310***e* is coupled to the piping so as to obtain measurements of the sulphur content of the bunker fuel. The measurements taken by the Coriolis transmitter **310***b*, the multi-variable transmitter **310***c*, and the sulphur analyzer are transmitted to the BRIE system through a Modbus and DC power junction box **310***f* installed on the skid **310**.

[0056] Additional quantities may be calculated by the Coriolis transmitter and/or multi-variable transmitter and provided to the BRIE system. For example, the mass flow weighted averages of the fluid temperature, inlet pressure, liquid density, fluid mixture density may be calculated by the Coriolis transmitter and the multi-variable transmitter as appropriate and transmitted to the BRIE system. In one implementation, the pertinent calculations and measurements are all performed by the Coriolis transmitter and multi-variable transmitter (and other measurement devices as appropriate), with the BRIE system simply displaying some or all of these items, and generating reports that include some or all of these items. In other implementations, the BRIE system can calculate some quantities based on the readings from the Coriolis transmitter and/or the multi-variable transmitter.

[0057] The skid **310** also includes an AC power junction box **310***h* for AC power wiring to the Coriolis transmitter **310***b* and sulphur analyzer **310***e*. A sulphur analyzer junction box **310***g* is included for wiring from the sulphur analyzer to the power inverter **320***f* and cargo pump switch **320***g*. A sampling pump **310***j* samples the bunker fuel and provides the sample to the sulphur analyzer **310***e*. The heat tracing **310***i* ensures the bunker fuel has an acceptable viscosity for the sulphur analyzer's measurement of the sulphur content. A bypass flow switch **310***k* detects when a bypass valve is opened to flow bunker fuel by the skid **310** (detects when the skid **310** is and is not being used). Quick disconnect style cable terminations can be used at all junction box terminations for reduced time to install or remove the skid **310**.

[0058] The BRIE system is installed in the vessel control room **320**. The BRIE system includes a computer (and monitor) **320***a* that is programmed to present the total mass transferred (e.g., in metric tons) and other parameters based on the measurements from the Coriolis transmitter **310***b*, multi-variable transmitter **310***c*, and sulphur analyzer **310***e*. For example, in addition to the total mass transferred, the computer **320***a* may present the mass flow weighted averages of the fluid temperature, inlet pressure, liquid density, fluid mixture density (when 2-Phase flow is detected), and sulphur content % m/m.

[0059] The computer **320***a* is also programmed to generate bunker transfer reports including some or all of the measurements or parameters derived from them. The bunker transfer reports can include, for example, bunker fuel temperature, pressure, total mass transferred, liquid mass flow rate, and mixture density throughout each bunker fuel transaction. The computer **320***a* may be programmed to create and archive the bunker transfer reports in an electronic file format (e.g., portable document format (PDF)), and to provide the ability to print the reports and forward them electronically (e.g., via File Transfer Protocol (FTP)) to any designated network storage location. The transfer reports may be archived for future reference or audit purposes. Bunker delivery batch totals and bunker receipt records may be held in secure tamper proof memory.

[0060] In addition, the computer **320***a* may be programmed to provide an HMI for the operator. The HMI can allow an operator to initiate online monitoring of the metering system, to graphically monitor the bunker fuel delivery, to end online monitoring, and to print or forward bunker transfer reports as a record of transfers from barges to ships. The HMI can caution the operator to end the online monitoring of the metering system before the delivery hose and deck piping are drained back through metering system pipework. In some implementations, the computer **320***a* also may generate bunker delivery notes for barge-to-ship or barge-to-barge custody transfers, and the HMI may allow the operator to print the bunker delivery notes as a record of the custody transfer transactions of a bunker barge. In addition, the computer **320***a* can be programmed to display the measured and calculated variables to sufficient resolution to enable calculations to be visually verified on the monitor, and to provide alarms to monitor the health of the metering system, such as high and low flowrate limits and instrument measurement failures.

[0061] The computer **320***a* may be programmed to maintain cumulative batch load registers for mass, mass in air, volume and standard volume. These registers may be designed to only be reset-able under an appropriate security code. A continuous remaining on board (ROB) bunker fuel calculation can be displayed by deducting each batch load to a ship (or other barge) from the cumulative load registers. The cumulative load registers can be designed to increment during a confirmed bunker vessel loading through the metering system to bunker tanks. The cumulative load registers also can be designed to decrement at the end of a bunker fuel delivery to a ship only when the delivery hose is drained back through the metering skid to bunker storage tanks.

[0062] The computer **320***a* can also be programmed to take into account (for example, by using an offset or other correction) for amounts of bunker fuel needed to fill piping on the bunker barge, or left in the piping on the bunker barge after deliveries. For example, a bunker vessel may start a series of deliveries with piping fully empty. On hook-up, bunker fuel is delivered through the metering system to the receiving ship, which may necessitate filling the bunker vessel's piping, including a length of piping between the metering system and a shut-off manifold valve. For some delivery procedures, on completion and end of bunker delivery, the barge pumps are stopped, the manifold valve is closed, and the hose between bunker vessel (outboard of the manifold valve) and receiving ship is purged with compressed air. The short length of piping between the metering system outlet and the manifold valve may not be drained back to the bunker vessel's tanks after the first (and subsequent) bunker delivery and therefore this section of pipe may remain full. Consequently, on the first in a series of deliveries, the bunker fuel quantity to fill this section of pipe (and which is measured by the metering system) may not actually be delivered to the ship and therefore the metered amount may be off by the amount in this section of pipe. But deliveries subsequent to the first (with piping full up to the manifold valve) would be metered correctly. An offset or other correction can be applied, for example, to the first delivery in the situation in which the piping starts fully empty.

[0063] In addition, for example, after the last of a series of deliveries, the piping may be drained back through the metering system and, unless corrected, the actual remaining bunker fuel in the barge tanks would be greater than that calculated (for example, by deducting the cumulative bunker deliveries) by the quantity in the piping between the metering system and manifold valve. A correction can also be applied to the calculated amount in the bunker tanks in this instance to account for the bunker fuel left in the piping.

[0064] The computer **320***a* is coupled to a Modbus Master Controller **320***b* (e.g., a Controller Model T2550 Modbus Master from Invensys Process systems of Plano, Tex.) or similar programmable logic controller (PLC) to provide for communication with the Coriolis transmitter **310***b*, the multivariable transmitter **310***c*, and the sulphur analyzer **310***d* through the Modbus junction box **310***f*.

[0065] The BRIE system can also include a printer **320***c* coupled to the computer to print out the bunker transfer or other reports, and an uninterruptible power supply **320***d* (UPS) to provide back-up power in the event the main power goes down. The UPS **320***d* may have a supply voltage of 208V AC at 50 to 60 Hz or other supply voltage. In the event of a power failure of the main supply voltage, the UPS **320***d* can be designed to provide an audible and/or a visual alarm. In the event of a sustained main supply power failure longer than a defined period of time, and before battery life of the UPS **320***d* is exhausted, the UPS **320***d* can be designed to communicate impending UPS shut down to the BRIE System to enable a safe shut down without damage to the BRIE System.

[0066] A wireless router **320***e* coupled to the computer **320***a* can provide for electronic ticketing capability by allowing for the uploading of bunkering transfer information via cellular or broadband wireless connectivity. For instance, the wireless router **320***e* can be used to send bunker transfer reports and bunker delivery notes to a client FTP site and can also provide clients with email notifications of bunker transfers with attached reports in electronic file format.

[0067] Other implementations may include additional measurements and associated equipment. For example, a viscometer may be included as part of the metering system to provide a measure of the bunker fuel's viscosity during the transfer. In another example, a water cut meter may be included to provide a measure of the bunker fuel's water concentration during the transfer. Such additional information can be used to further validate the quantity measurement and/or validate the quality of the bunker fuel.

[0068] FIGS. **4** and **5** illustrate an example of a skid **400**. The skid **400** can be an open frame construction that is 8 ft. high×8 ft. wide×10 ft. long and that conforms to ISO 1496-1 dimensions with DIN ISO1611 corner castings. The flowtube **402**, piping **404**, multi-variable transmitter, Coriolis transmitter, and junction boxes can all be installed within the skid framework and not protrude outside of the skid framework. The piping **404** coupled to the flowtube **402** may be 8" piping. The flowtube **402** can be mounted in the vertical plane and with the inlet flow in the upward direction. The skid inlet **404***a* and outlet piping **404***b* may have 8" PN16 flange connections **406***a* and **406***b*, respectively, or other size flange connections.

A first canopy **408** may be provided to house the multi-variable transmitter and Coriolis transmitter and a second canopy **410** may be provided to house the sulphur analyzer and/or other meters. Also, bypass piping can be provided with a bypass valve to route bunker fuel from the inlet to the outlet without passing through the Coriolis flowmeter.

[0069] The skid can have a weight distribution such that the center of gravity is roughly central to the skid framework to facilitate balanced lifting and transport of the skid. The skid can be of a modular construction such that the skid can be easily installed and removed from bunker barge decks with a standardized container mounting arrangement where twist lock base fittings are secured at skid frame corners.

[0070] The 8'×8'×10' Skid frame can be considered a half "Twenty-Foot Equivalent Unit" (TEU) container, with the possibility that two skids can be twist-locked together in tandem to form an 8'×8'×20' container frame that can be readily lifted, stacked and container ship transported the same as a standard 20' shipping container.

[0071] Cabling within the skid and cable extending to the vessel control room can generally be in accordance with IEC 60092 and also meet marine and local regulations for shipboard use where IEC 60092 is exceeded. The flowmeter, associated instrumentation and junction boxes can have provision for wire and lead tamper-proof seals to be fitted to all points of adjustment and connection.

[0072] Referring to FIG. **6**, the skid **400** is installed on the deck **420** of a bunker barge. The skid inlet piping **404***a* is coupled to a first conduit **422** via the flange connection **406***a*. The first conduit provides bunker fuel from the bunker barge. The skid outlet piping **404***b* is coupled to a second conduit **424** via the flange connection **406***b*. The second conduit **424** is configured to provide the bunker fuel to the receiving vessel. During a delivery, the bunker fuel flows through the first conduit **422**, into the skid inlet piping **404***a*, through the flowtube **402**, out the outlet piping **404***b*, and through the second conduit **424** to the receiving vessel.

[0073] Referring to FIG. **7**, an example of the BRIE system **700** includes an industrial enclosure **702**, such as a rack mounting cabinet (e.g., a 19" cabinet). The cabinet **702** can contain some or all of the components of the BRIE system **700**, such as the Modbus controller **704**, the computer and monitor **706**, a keyboard and mouse **708** for interacting with the computer, the laser printer **710**, and the UPS **712**.

[0074] Referring to FIGS. **8**A and **8**B, instead of on a skid, a simplified multi-measurement metering system **800** can be implemented. For instance, flanged piping spool pieces (e.g., Class **300** weld neck flanged piping spool pieces) **802***a* and **802***b* can be coupled to the inlet **806***a* and outlet **806***b* of the Coriolis flowtube **804**, and provide for close coupled mounting of the multi-variable transmitter **810** (including pressure seals **808***a* and **808***b*), the resistance temperature detector (RTD) **812**, and Coriolis transmitter **814** directly to the flowtube inlet and outlet flanges. For instance, the high pressure seal **808***a* for the multi-variable transmitter **810** and the RTD **812** can be mounted on the inlet piping spool piece **802***a*. The low pressure seal **808***b* for the multi-variable transmitter **810**, the multi-variable transmitter **810**, and the Coriolis transmitter **814** can be mounted on the outlet piping spool piece **802***b*. This simplified multi-measurement metering system arrangement **800** may be well suited for ship mounting either below or above deck, and may take up much less space than the modular skid arrangement, which can be better suited for bunker barges. The flowtube **804** can be mounted in the vertical plane and with the inlet flow in the upward direction, or in various mounting planes for inlet flow in various other directions. In the implementation shown the sulphur meter is not used, but a sulphur meter or other instruments (for example viscometer or water cut meter) can be used in the near vicinity of the metering system to monitor fuel quality.

[0075] FIGS. **9**A-**9**C show an example of a bunker transfer report **900**. Referring to FIG. **9**A, a summary section of the report **900** includes a first table **902**, a second table **904**, and a third table **906**. The first table **902** includes information about the transfer, such as the port name, the barge name, the vessel name, the product id, the transaction number, the transfer start time, the transfer end time, and the duration of the transfer. The second table **904** includes the total mass transferred. The third table **906** includes some quality information, such as the mass weight average, the minimum value, and the maximum value of the fluid temperature, inlet pressure, mixture density, liquid density at line conditions, sulphur content (if a sulphur analyzer is included as part of the metering system), and viscosity (if a viscometer is included as part of the metering system).

[0076] Referring to FIGS. **9**B and **9**C, the rest of the report **900** includes graphs showing various conditions during the transfer. A liquid massflow graph **908** shows the liquid mass flowrate measured by the Coriolis flowmeter during the transfer. A mixture density graph **910** shows the mixture density measured by the Coriolis flowmeter during the transfer. A fluid temperature graph **912** shows the fluid temperature measured by the RTD and multi-variable transmitter during the transfer. An inlet pressure graph **914** and a differential pressure graph **916** show the pressures measured by the multi-variable transmitter and pressure sensors during the transfer.

[0077] With continued reference to FIGS. **9**B and **9**C, the graphs show mid way through the bunker transfer (beginning around 7:30 and lasting until about 8:45) an extended period of a two-phase (with entrained air) flow condition that the Coriolis flowmeter has detected, validating the significant effects on the real-time liquid mass flow and mixture density measurements during two-phase (with entrained air) flowing conditions. Also apparent is the tank stripping process noted at the end of the bunker transfer (starting around 10:30) where the bunker barge tank is pumped dry and air becomes pumped into the remaining bunker fuel that is pumped from the bottom of the bunker barge tank. The fluid temperature graph **912** also shows the varying bunker fuel temperature during the bunker transfer, confirming the increasing trend of the liquid mass flow rate shown in the liquid mass flow graph **908** during the latter part of the bunker transfer where the measured temperature is increasing.

[0078] FIGS. **10**A-**10**C show an example of an alternative bunker transfer report **1000**. Referring to FIG. **10**A, similar to the report **900**, the report **1000** includes a summary page that includes a first table **1002**, a second table **1004**, and a third table **1006**. The first table **1002** and the third table **1006** in the report **1000** include the same information as the first table **902** and the third table **906** in the report **900**. The second table **1004** in the report **1000** includes the total mass transferred and the total apparent mass in air (as defined in ASTM D1250 IP200 Petroleum Measurement Table 56, Weight in Air correction factors). In addition, the second table **1004** in the report **1000** also includes information related to entrained air in the bunker fuel, such as the total mass transferred in single phase (without entrained air) in terms of mass (metric tons), the total mass transferred in two-phase (with entrained air) in terms of mass (metric tons), and the total mass transferred in two-phase (with entrained air) as a percentage of the total mass transferred.

[0079] Referring to FIGS. **10**B and **10**C, the report **1000** also includes a liquid massflow graph **1008**, a mixture density graph **1010**, a fluid temperature graph **1014**, an inlet pressure graph **1016**, and a differential pressure graph **1018**. However, in addition to these graphs, the report **1000** also includes a cumulative liquid massflow total graph **1012** and a downstream pressure graph **1020**. The cumulative liquid massflow total graph **1012** shows the total mass transferred over the course of the transfer, as calculated by the BRIE system from the mass flowrate measurements obtained from the Coriolis flowmeter. The downstream pressure graph **1020** shows the pressure at the outlet of the metering system as measured by the pressure sensors and the multi-variable transmitter during the transfer.

[0080] With continued reference to FIGS. **10**B and **10**C, the graphs show later in the bunker transfer (around 10:15) where the bunker barge pumping was switched from one bunker fuel tank to another bunker fuel tank with an intermittent drop in the mass flow rate as shown in the liquid mass flow graph **1008**. Also apparent is the tank stripping process noted at the end of the bunker transfer (around 10:45) where the bunker barge tank is pumped dry and air becomes pumped into the remaining bunker fuel that is pumped from the bottom of the bunker barge tank. The cumulative liquid mass flow total graph **1012** shows the progress during the bunker fuel transfer and time to complete the bunker fuel transfer to achieve the receiving ship's ordered mass of bunker fuel to be delivered.

[0081] FIG. **11** shows an example of a bunker delivery note that may be generated by the BRIE system. As described above, in addition to metering transfers from a bunker barge to a ship, the bunker fuel transfer system also may be used to meter transfer of bunker fuel between barges. Bunker delivery notes are typical for such transfers, and the BRIE system may automatically generate such a bunker delivery note (with the appropriate information included in the note for the transfer).

[0082] FIGS. **12-19** show examples of screens that may be displayed by the BRIE system to allow for real-time monitoring of the bunker fuel transfer. FIG. **12**A shows an example of a screen **1200**A that allows the various parameters measured by the multi-measurement metering skid system to be monitored. For example, screen **1200**A displays the inlet temperature **1202**, the inlet pressure **1204**, and the outlet pressure **1206**. The screen **1200**A also includes an icon **1208** that shows whether the bypass valve is open or closed (with arrows showing the flow of fluid through the bypass piping when the bypass valve is open or through the flowtube when the bypass valve is closed). The parameters measured by the flowmeter (for example, the mass flow, the density, and the total mass transferred) are also displayed on the screen **1200**A in graphic **1210**. The graphic **1210** also shows the pressure drop between the inlet and the outlet. An icon **1212** on the screen **1200**A also displays the sulphur content. In addition, the screen **1200**A includes information **1214** about the particularly deliver, such as the time the delivery commenced, when the delivery was completed (or if it is currently active), and the elapsed time since the beginning of the delivery. The icons **1216** allow the operator to start and stop the bunker fuel transfer online metering of the delivery.

[0083] FIG. **12**B shows another example of a screen **1200**B that allows the various parameters measured by the multi-measurement metering skid system to be monitored. In addition to the information shown in the screen **1200**A, the screen **1200**B includes additional information regarding the transfer, such as the amount ordered, the percentage of the delivery that is complete, and the estimated time remaining for the delivery. This information is shown in graphic **1218** with the mass flowrate, the density, the deliver start time and date, the elapsed time since the beginning of the delivery, the time and date of the delivery end when it occurs, and the icons **1216** for starting and stopping the bunker fuel transfer online metering of the delivery. The differential pressure is shown by graphic **1220**.

[0084] FIG. **13**A shows an example of an operator interface screen **1300**A where various parameters measured by the simplified metering system can be monitored and where the operator can also initiate the start of and the end of the online monitoring of the bunker fuel transfer with a simplified multi-measurement metering and BRIE system. Similar to screen **1200**A, screen **1300**A includes the inlet temperature **1302**, the inlet pressure **1304**, and the outlet pressure **1306**. Screen **1300**A also includes a graphic **1310** that shows the mass flowrate, the density, the total mass delivered, and the pressure drop between the inlet and outlet. In addition, the screen **1300**A includes information **1314** about the particularly deliver, such as the time the delivery commenced, when the delivery was completed (or if it is currently active), and the elapsed time since the beginning of the delivery. Icons **1316** can be used by the operator to start and stop the bunker fuel transfer online metering of the delivery.

[0085] FIG. **13**B shows another example of an operator interface screen **1300**B where various parameters measured by the metering system can be monitored and where the operator can also initiate the start of and the end of the online monitoring of the bunker fuel transfer with a simplified multi-measurement metering and BRIE system. In addition to the information shown in the screen **1300**A, the screen **1300**B includes additional information regarding the transfer, such as the amount ordered, the percentage of the delivery that is complete, and the estimated time remaining for the delivery. This information is shown in graphic **1318** with the mass flowrate, the density, the deliver start time and date, the elapsed time since the beginning of the delivery, the time and date of the delivery end when it occurs, and the icons **1316** for starting and stopping the bunker fuel transfer online metering of the delivery. The differential pressure is shown by graphic **1320**.

[0086] FIG. **14** shows an example of an operator interface screen where the operator would enter various details of the bunker transaction such as receiving ship name, grade of bunker fuel, cargo officer, etc. This information is reflected in area **1402**. Information about the quantity delivered is shown in an area **1404**. Icon **1406** can be used by the operator to start and stop the bunker fuel transfer online metering of the delivery.

[0087] FIGS. **15-17** show examples of screens that display various parameters related to the Coriolis flowmeter so that the Coriolis flowmeter's performance can be monitored during the transfer.

[0088] FIG. **18** shows an example of a screen **1800** that displays various parameters of the multi-variable transmitter, including measurements **1802** made by the multi-variable transmitter, so that the multi-variable transmitter's performance can be monitored during the transfer.

[0089] FIG. **19** shows an example of a screen **1900** that displays various parameters of the sulphur analyzer, including measurements **1902** made by sulphur analyzer, so that the sulphur analyzer's performance can be monitored during the transfer. While not shown, other screens may be provided, for example, if other measurement devices are additionally included, such as a viscometer or water cut meter.

[0090] Various implementations may be designed in compliance with a range of national and international standards and environmental conditions.

[0091] Various implementations can provide one or more of the following advantages. For instance, implementations may provide highly accurate digital flow measurement of bunker fuel transfers with real-time monitoring of temperature, pressure, density and flow rate parameters. Implementations may detect air entrainment and compensate to measure net mass of the actual bunker fuel delivered and/or provide continuous measurements and data logging throughout bunker delivery. Implementations may provide accurate measurement of delivery quantity and provide other indicators of quality. Implementations may provide electronic bunker transfer reports with graphs and trends of temperature, pressure, density and flow rate variations throughout each bunker fuel transfer that can be used in support of bunker delivery notes to provide an 'irrefutable' bunker delivery note or other receipt, thereby minimizing discrepancies and disputes of bunker delivery transactions. Such reports also may provide insight into bunker barge fuel transfer process variability to reduce tank-stripping practices or other fraudulent or negligent practices. Such reports may further provide accurate and robust records of bunker deliveries (electronic audit trail), and provide for rapid collation, logging, transmission and presentation of bunker delivery data in an electronic format.

What is claimed is:

1. A bunker fuel transfer system comprising:

a Coriolis flowmeter having a flowtube, the flowtube having an inlet that is configured to be coupled to a first conduit that provides bunker fuel from a bunker barge and an outlet that is configured to be coupled to a second conduit that provides the bunker fuel to a receiving vessel, wherein the Coriolis flowmeter is configured to measure a flowrate of the bunker fuel as the bunker fuel flows through the flowtube;

at least one sensor configured to measure a parameter of the bunker fuel as the bunker fuel flows through the flowtube; and

a computing system configured to receive the measured flowrate from the Coriolis flowmeter, receive the measured parameter from the sensor, and generate a bunker transfer report based on the received flowrate and the received parameter, the bunker transfer report including a total amount of the bunker fuel that is transferred from the bunker barge to the receiving vessel and information related to the parameter measured by the sensor.

2. The system of claim **1** wherein the bunker transfer report includes one or more graphs displaying the measured flowrate of the bunker fuel over time and the measured parameter over time.

3. The system of claim **1** wherein the Coriolis flowmeter is configured to measure a mixture density of the bunker fuel with entrained air as the bunker fuel flows through the flowtube.

4 The system of claim **3** wherein the bunker transfer report includes information related to the mixture density.

5. The system of claim **4** wherein the bunker transfer report includes one or more graphs displaying the mixture density over time.

6. The system of claim **1** wherein the Coriolis flowmeter is configured to detect when air is entrained in the bunker fuel as the bunker fuel flows through the flowtube.

7. The system of claim **6** wherein the bunker transfer report includes information related to the air entrained in the bunker fuel as the bunker fuel flows through the flowtube.

8. The system of claim **1** wherein the bunker transfer report includes one or more graphs displaying the total amount of bunker fuel transferred over time.

9. The system of claim **1** wherein the at least one sensor comprises a temperature sensor and the parameter comprises a temperature at the inlet of the flowtube.

10. The system of claim **1** wherein the at least one sensor comprises a pressure sensor and the parameter comprises a pressure at the inlet or outlet of the flowtube.

11. The system of claim **1** wherein the at least one sensor comprises two pressures sensors and the parameter comprises a differential pressure between the inlet and outlet of the flowtube.

12. The system of claim **1** wherein the bunker transfer report includes information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube.

13. The system of claim **12** further comprising one or more of a viscometer configured to measure a viscosity of the bunker fuel as the bunker fuel flows through the flowtube, a water cut meter configured to measure a water content of the bunker fuel as the bunker fuel flows through the flowtube, or a sulphur analyzer configured to measure a sulphur content of the bunker fuel as the bunker fuel flows through the flowtube.

14. The system of claim **13** wherein the information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube comprises information related to the viscosity of the bunker fuel measured by the viscometer, information related to the water content of the bunker fuel measured by the water cut meter, or information related to the sulphur content of the bunker fuel measured by the sulphur analyzer.

15. The system of claim **1** further comprising a multi-variable transmitter configured to transfer the measured parameter from the at least one sensor to the computing system.

16. The system of claim **1** wherein the computing device is configured to display information related to the flowrate and the measured parameter on a display device.

17. A method comprising:

coupling an inlet of a flowtube of a Coriolis flowmeter to a first conduit that provides bunker fuel from a bunker barge;

coupling an outlet of the flowtube to a second conduit that provides the bunker fuel to a receiving vessel;

measuring a flowrate of the bunker fuel using the Coriolis flowmeter as the bunker fuel flows through the flowtube;

measuring a parameter of the bunker fuel using at least one sensor as the bunker fuel flows through the flowtube; and

generating a bunker transfer report based on the measured flowrate and the measured parameter, the bunker transfer report including a total amount of the bunker fuel that is transferred from the bunker barge to the receiving vessel and information related to the parameter measured by the sensor.

18. The method of claim **17** wherein the bunker transfer report includes one or more graphs displaying the measured flowrate of the bunker fuel over time and the measured parameter over time.

19. The method of claim **17** further comprising measuring, using the Coriolis flowmeter, a mixture density of the bunker fuel with entrained air as the bunker fuel flows through the flowtube.

20. The method of claim **19** wherein the bunker transfer report includes information related to the mixture density.

21. The method of claim **20** wherein the bunker transfer report includes one or more graphs displaying the mixture density over time.

22. The method of claim **17** further comprising detecting, using the Coriolis flowmeter, when air is entrained in the bunker fuel as the bunker fuel flows through the flowtube.

23. The method of claim **22** wherein the bunker transfer report includes information related to the air entrained in the bunker fuel as the bunker fuel flows through the flowtube.

24. The method of claim **17** wherein the bunker transfer report includes one or more graphs displaying the total amount of bunker fuel transferred over time.

25. The method of claim **17** wherein the at least one sensor comprises a temperature sensor and the parameter comprises a temperature at the inlet of the flowtube.

26. The method of claim **17** wherein the at least one sensor comprises a pressure sensor and the parameter comprises a pressure at the inlet or outlet of the flowtube.

27. The method of claim **17** wherein the at least one sensor comprises two pressures sensors and the parameter comprises a differential pressure between the inlet and outlet of the flowtube.

28. The method of claim **17** wherein the bunker transfer report includes information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube.

29. The method of claim **28** further comprising measuring a viscosity of the bunker fuel as the bunker fuel flows through the flowtube, measuring a water content of the bunker fuel as the bunker fuel flows through the flowtube, or measuring a sulphur content of the bunker fuel as the bunker fuel flows through the flowtube.

30. The system of claim **29** wherein the information related to the quality of the bunker fuel as the bunker fuel flows through the flowtube comprises information related to the measured viscosity of the bunker fuel, information related to the measured water content of the bunker fuel, or information related to the measured sulphur content of the bunker fuel.

31. The method of claim **17** further comprising transmitting the measured parameter from the at least one sensor to a computing system using a multi-variable transmitter.

32. The method of claim **17** further comprising displaying information related to the flowrate and the measured parameter on a display device.

* * * * *