United States Patent [19]

Smith, Jr. et al.

[11] 3,802,236

[45] Apr. 9, 1974

[54] **GAUGE CONTROL METHOD AND APPARATUS INCLUDING WORKPIECE GAUGE DEVIATION CORRECTION FOR METAL ROLLING MILLS**

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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

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[21] Appl. No.: **215,749**

[52] **U.S. Cl.** **72/11,** 72/16

[51] **Int. Cl.** **B21b 37/00**

[58] **Field of Search** 72/6–12, 16, 72/19, 21

[56] **References Cited**

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3,186,201	6/1965	Ludbrook et al.	72/9
3,631,697	1/1972	Deramo et al.	72/8
3,568,637	5/1971	Smith, Jr.	72/8
3,574,280	4/1971	Smith, Jr.	72/8
3,552,162	1/1971	Gingher, Jr. et al.	72/16 X

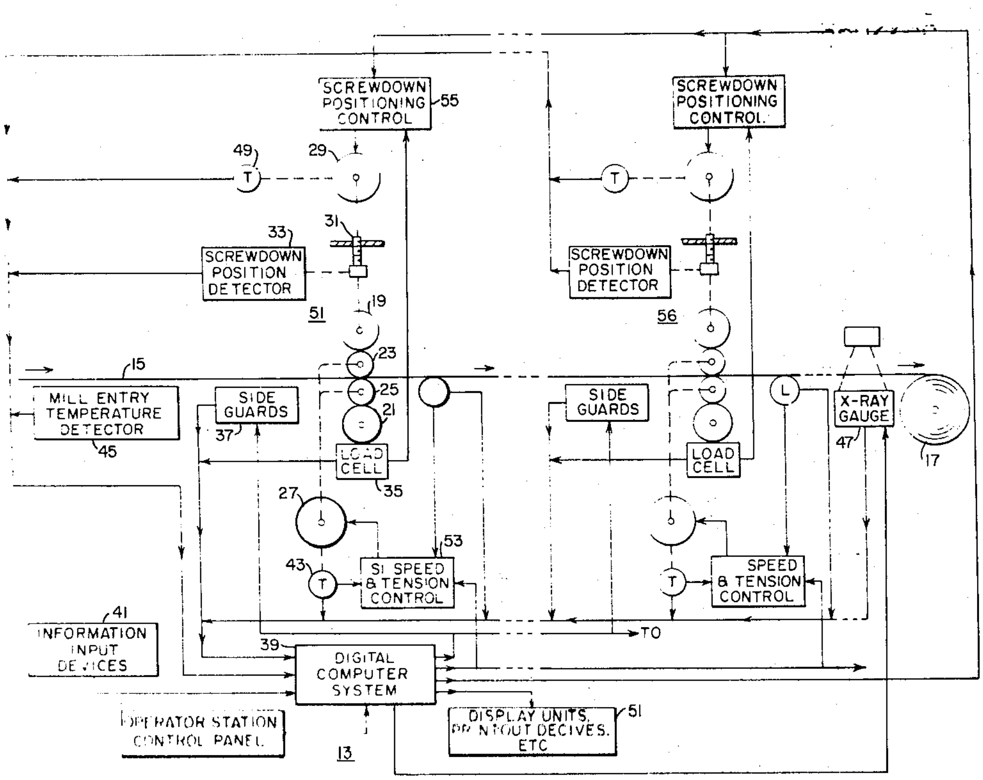
Primary Examiner—Milton S. Mehr

Attorney, Agent, or Firm—R. G. Brodahl

[57] **ABSTRACT**

A programmed computer control system provides on line roll force gauge control for a tandem hot steel strip rolling mill. An automatic gauge control system including a programmed digital computer calculates screwdown movement required for correction of determined gauge error on the basis of measured roll force and screwdown position values and on the basis of calculated gauge deviation corrections for the provided roll opening settings for the roll stands. To compensate for gauge error conditions, a gauge error correcting screwdown movement value is determined to establish the total amount of corrective screwdown movement required at any particular point in time. The control system operates the mill screwdowns in accordance with the program calculations.

13 Claims, 14 Drawing Figures



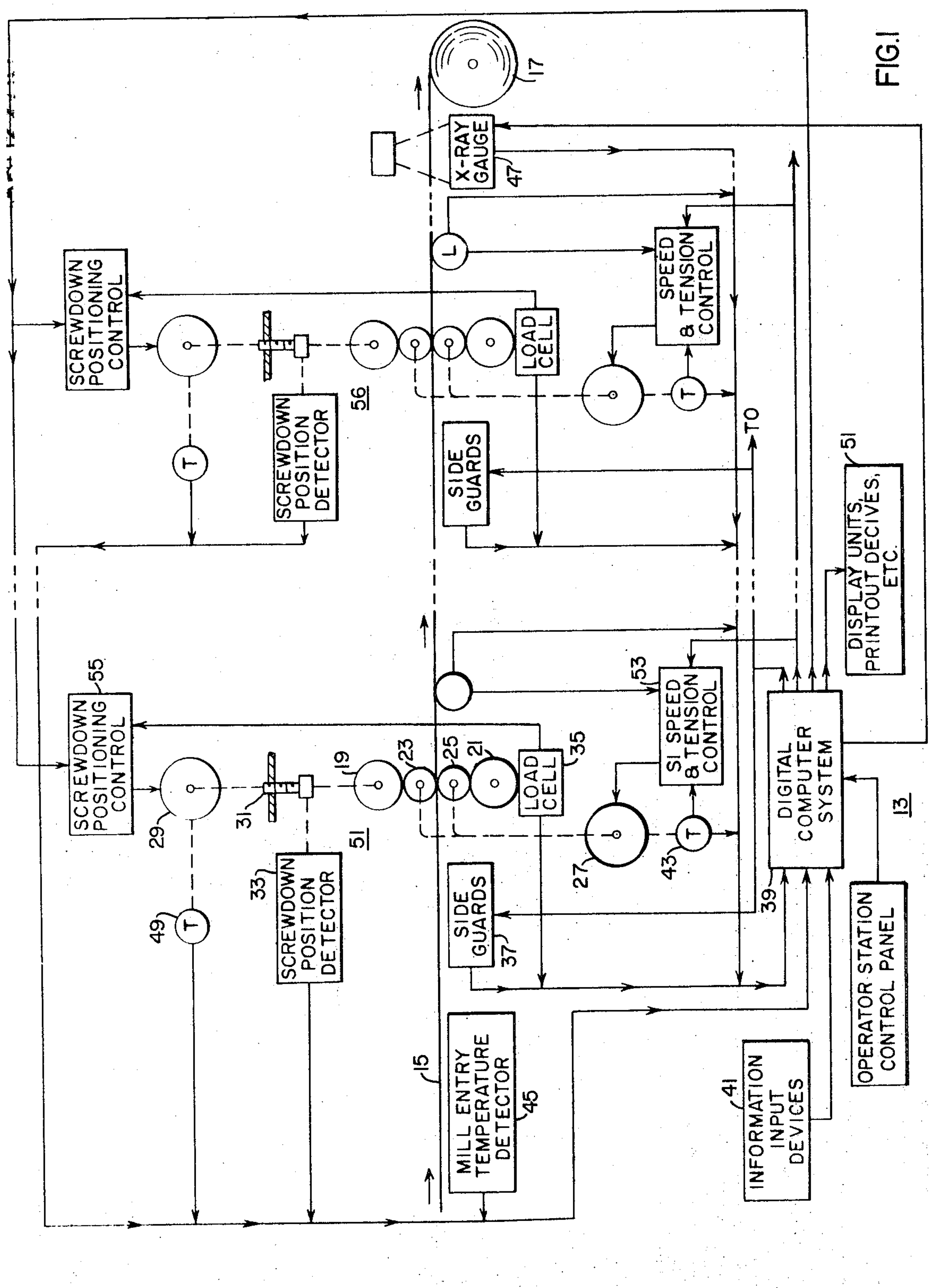

SCREWDOWN POSITIONING CONTROL
SCREWDOWN POSITION DETECTOR
56
T
L
LOAD CELL
SPEED & TENSION CONTROL
X-RAY GAUGE
47
17
SIDE GUARDS
TO
51
DISPLAY UNITS, PRINTOUT DECIVES, ETC.
55
SCREWDOWN POSITIONING CONTROL
29
31
19
23
25
21
51
53
SI SPEED & TENSION CONTROL
35
LOAD CELL
27
43
33
SCREWDOWN POSITION DETECTOR
49
SIDE GUARDS
37
39
DIGITAL COMPUTER SYSTEM
13
OPERATOR STATION CONTROL PANEL
MILL ENTRY TEMPERATURE DETECTOR
45
15
41
INFORMATION INPUT DEVICES

FIG.I

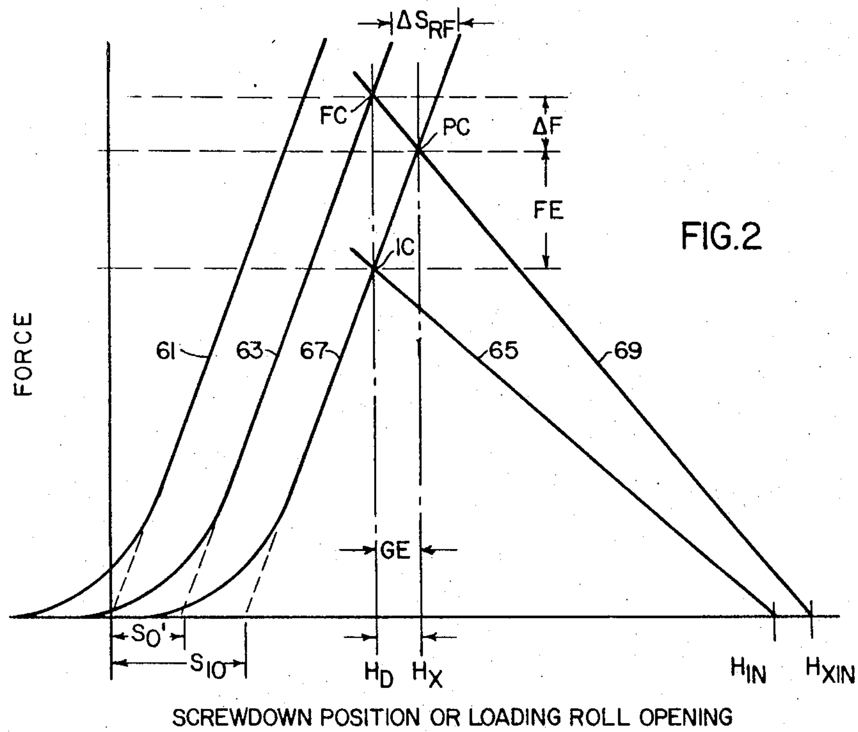
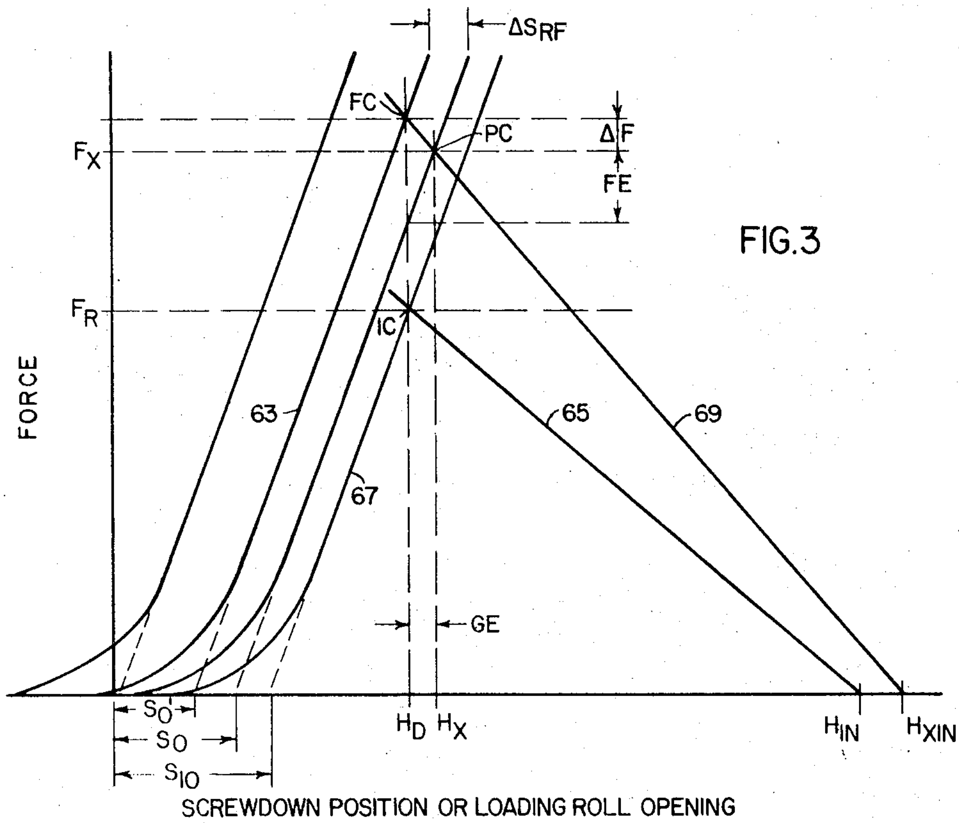

ΔS_RF
FC
PC
ΔF
FE
IC
FORCE
61
63
67
65
69
GE
S_O'
S_IO
H_D
H_X
H_IN
H_XIN
SCREWDOWN POSITION OR LOADING ROLL OPENING

FIG.2


ΔS_RF
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IC
FORCE
63
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69
67
GE
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S_IO
H_D
H_X
H_IN
H_XIN
SCREWDOWN POSITION OR LOADING ROLL OPENING

FIG.3

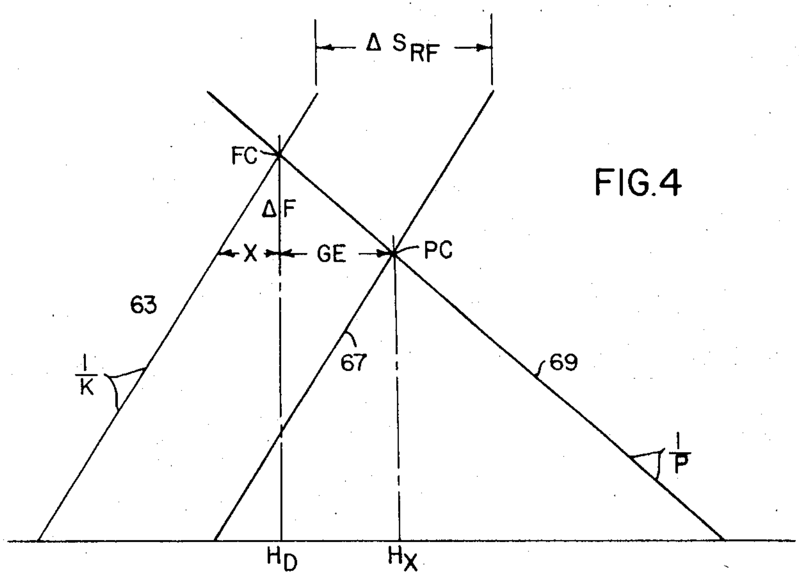
Δ S_{RF}
FC
ΔF
X
GE
PC
63
1/K
67
69
1/P
H_D
H_X

FIG.4

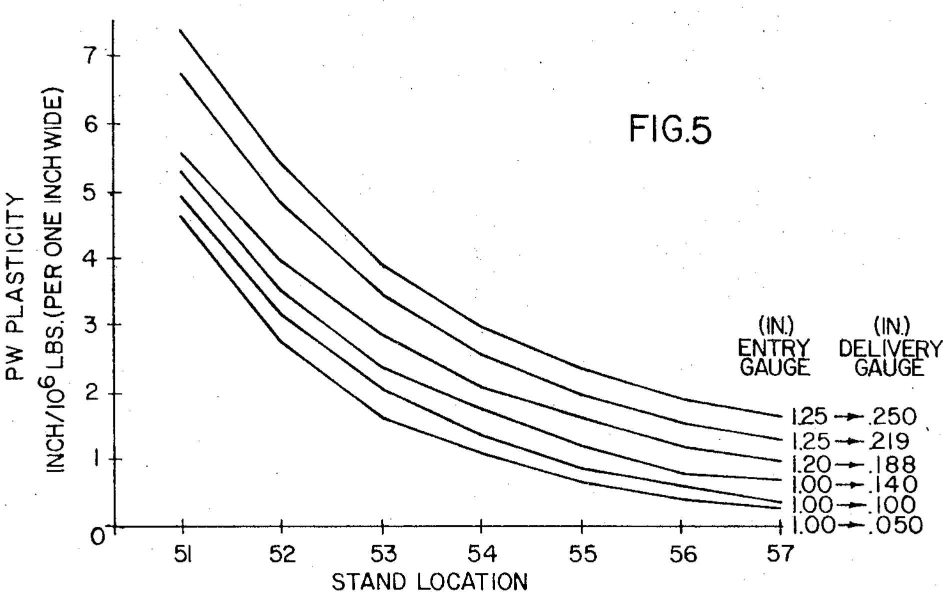
PW PLASTICITY
INCH/10⁶ LBS.(PER ONE INCH WIDE)
0
1
2
3
4
5
6
7
51
52
53
54
55
56
57
STAND LOCATION
(IN.) ENTRY GAUGE
(IN.) DELIVERY GAUGE
1.25 → .250
1.25 → .219
1.20 → .188
1.00 → .140
1.00 → .100
1.00 → .050

FIG.5

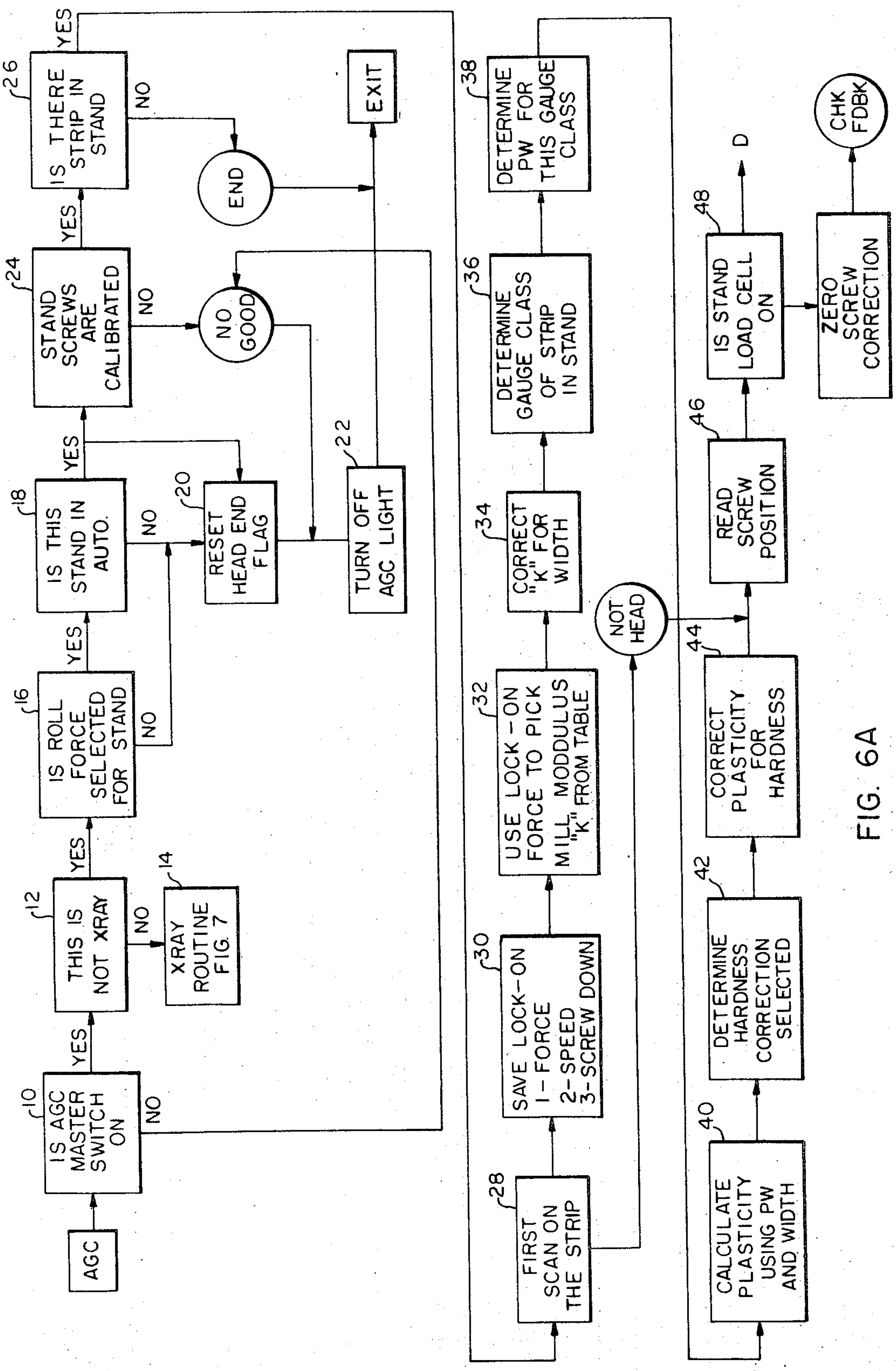
AGC
IS AGC MASTER SWITCH ON
YES
NO
10
THIS IS NOT XRAY
12
NO
XRAY ROUTINE FIG. 7
14
IS ROLL FORCE SELECTED FOR STAND
16
IS THIS STAND IN AUTO.
18
RESET HEAD END FLAG
20
TURN OFF AGC LIGHT
22
STAND SCREWS ARE CALIBRATED
24
NO GOOD
IS THERE STRIP IN STAND
26
END
EXIT
FIRST SCAN ON THE STRIP
28
SAVE LOCK-ON 1-FORCE 2-SPEED 3-SCREW DOWN
30
USE LOCK-ON FORCE TO PICK MILL MODDULUS "K" FROM TABLE
32
CORRECT "K" FOR WIDTH
34
DETERMINE GAUGE CLASS OF STRIP IN STAND
36
DETERMINE PW FOR THIS GAUGE CLASS
38
NOT HEAD
CALCULATE PLASTICITY USING PW AND WIDTH
40
DETERMINE HARDNESS CORRECTION SELECTED
42
CORRECT PLASTICITY FOR HARDNESS
44
READ SCREW POSITION
46
IS STAND LOAD CELL ON
48
D
ZERO SCREW CORRECTION
CHK FDBK

FIG. 6A

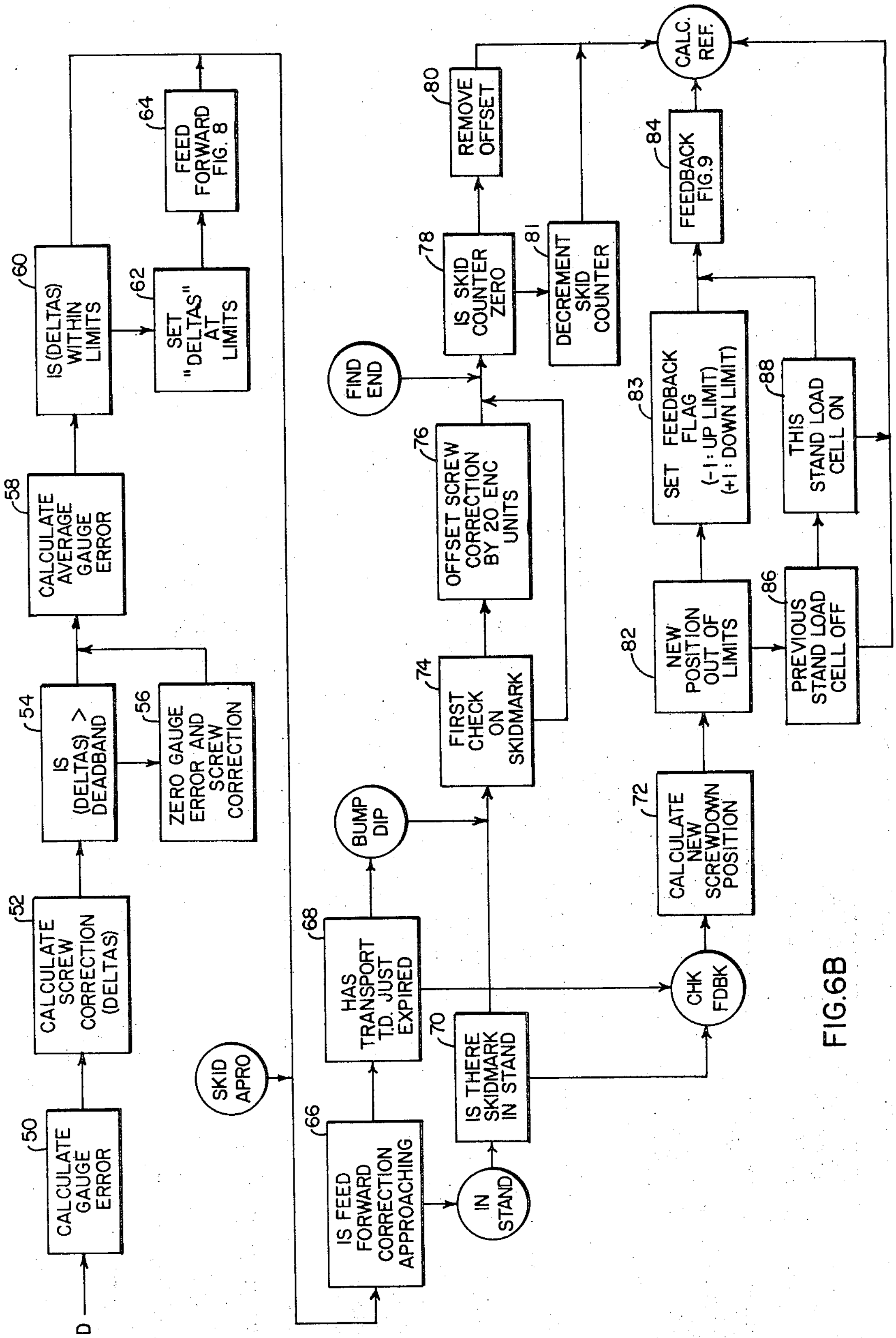
D
CALCULATE GAUGE ERROR
50
CALCULATE SCREW CORRECTION (DELTAS)
52
IS (DELTAS) > DEADBAND
54
ZERO GAUGE ERROR AND SCREW CORRECTION
56
CALCULATE AVERAGE GAUGE ERROR
58
IS (DELTAS) WITHIN LIMITS
60
SET "DELTAS" AT LIMITS
62
FEED FORWARD FIG. 8
64
SKID APRO
IS FEED FORWARD CORRECTION APPROACHING
66
IN STAND
HAS TRANSPORT T.D. JUST EXPIRED
68
BUMP DIP
IS THERE SKIDMARK IN STAND
70
CHK FDBK
CALCULATE NEW SCREWDOWN POSITION
72
FIRST CHECK ON SKIDMARK
74
OFFSET SCREW CORRECTION BY 20 ENC UNITS
76
FIND END
IS SKID COUNTER ZERO
78
REMOVE OFFSET
80
DECREMENT SKID COUNTER
81
NEW POSITION OUT OF LIMITS
82
SET FEEDBACK FLAG (-1 : UP LIMIT) (+1 : DOWN LIMIT)
83
FEEDBACK FIG.9
84
PREVIOUS STAND LOAD CELL OFF
86
THIS STAND LOAD CELL ON
88
CALC. REF.

FIG.6B

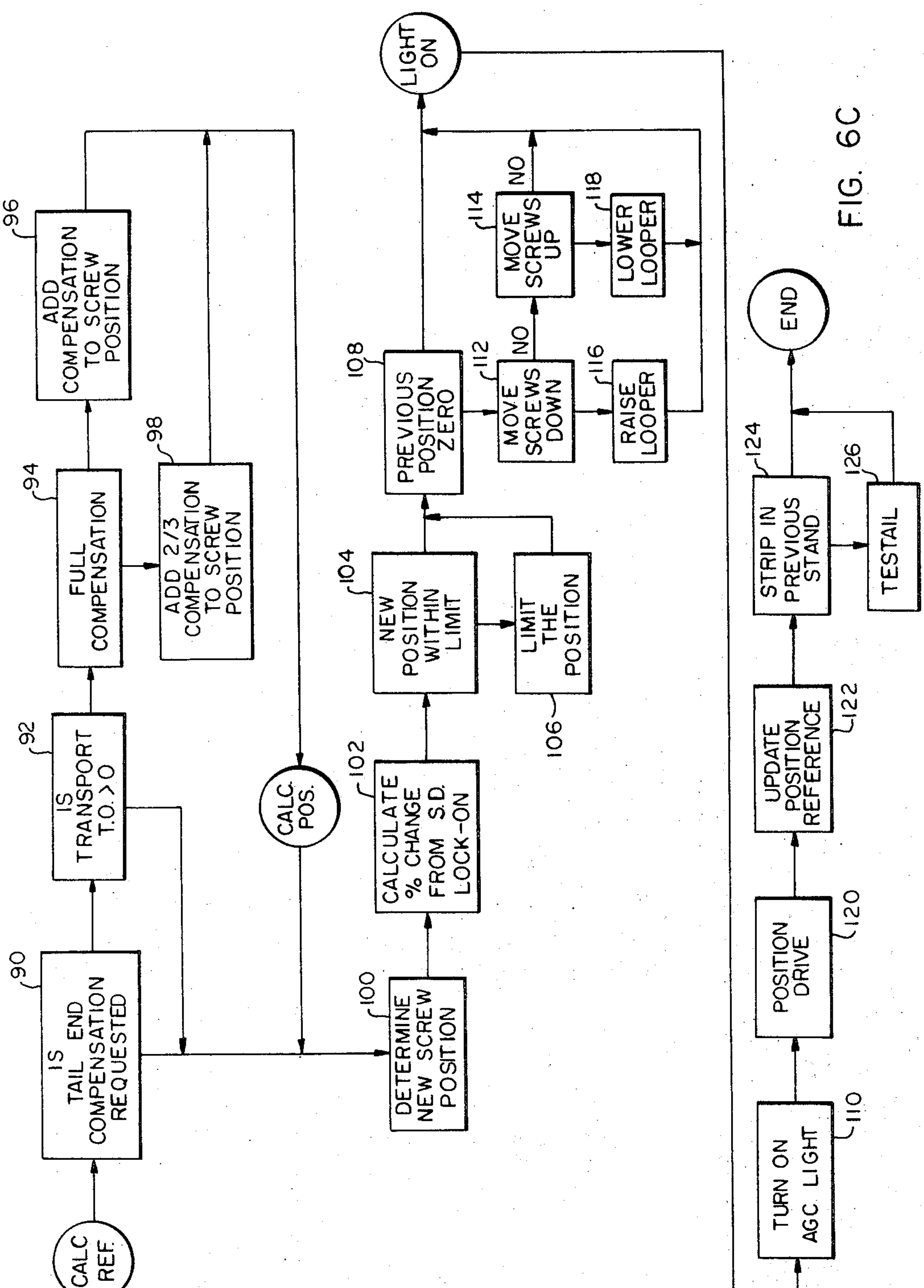
CALC REF
IS TAIL END COMPENSATION REQUESTED
90
IS TRANSPORT T.O.>O
92
FULL COMPENSATION
94
ADD COMPENSATION TO SCREW POSITION
96
ADD 2/3 COMPENSATION TO SCREW POSITION
98
CALC. POS.
DETERMINE NEW SCREW POSITION
100
CALCULATE % CHANGE FROM S.D. LOCK-ON
102
NEW POSITION WITHIN LIMIT
104
LIMIT THE POSITION
106
PREVIOUS POSITION ZERO
108
LIGHT ON
MOVE SCREWS DOWN
112
NO
MOVE SCREWS UP
114
NO
RAISE LOOPER
116
LOWER LOOPER
118
TURN ON AGC LIGHT
110
POSITION DRIVE
120
UPDATE POSITION REFERENCE
122
STRIP IN PREVIOUS STAND
124
TESTAIL
126
END

FIG. 6C

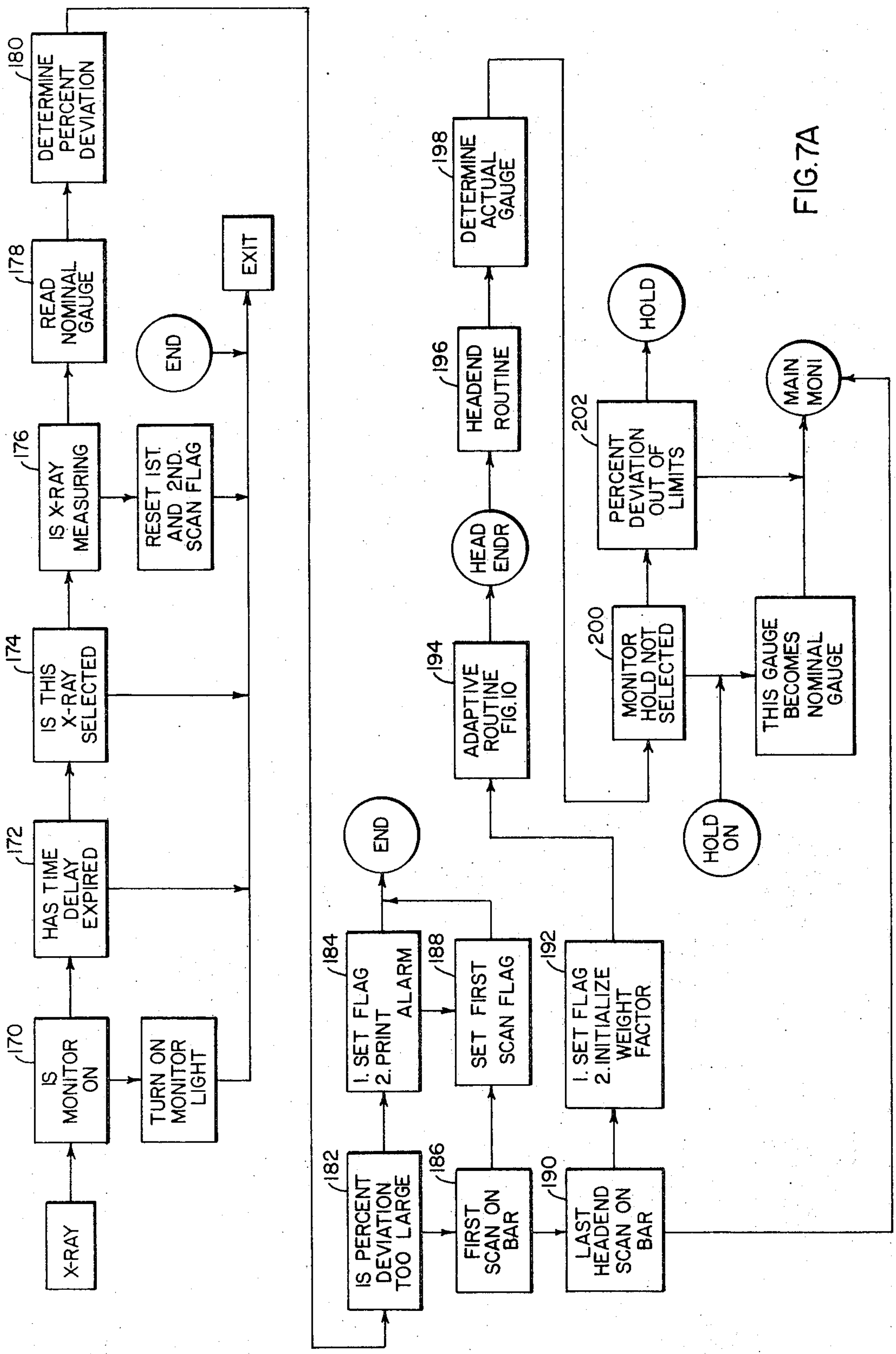
X-RAY
IS MONITOR ON
170
TURN ON MONITOR LIGHT
HAS TIME DELAY EXPIRED
172
IS THIS X-RAY SELECTED
174
IS X-RAY MEASURING
176
RESET IST. AND 2ND. SCAN FLAG
READ NOMINAL GAUGE
178
END
EXIT
DETERMINE PERCENT DEVIATION
180
IS PERCENT DEVIATION TOO LARGE
182
I. SET FLAG 2. PRINT ALARM
184
END
FIRST SCAN ON BAR
186
SET FIRST SCAN FLAG
188
LAST HEADEND SCAN ON BAR
190
I. SET FLAG 2. INITIALIZE WEIGHT FACTOR
192
ADAPTIVE ROUTINE FIG.10
194
HEAD ENDR
HEADEND ROUTINE
196
DETERMINE ACTUAL GAUGE
198
MONITOR HOLD NOT SELECTED
200
HOLD ON
THIS GAUGE BECOMES NOMINAL GAUGE
PERCENT DEVIATION OUT OF LIMITS
202
HOLD
MAIN MONI

FIG.7A

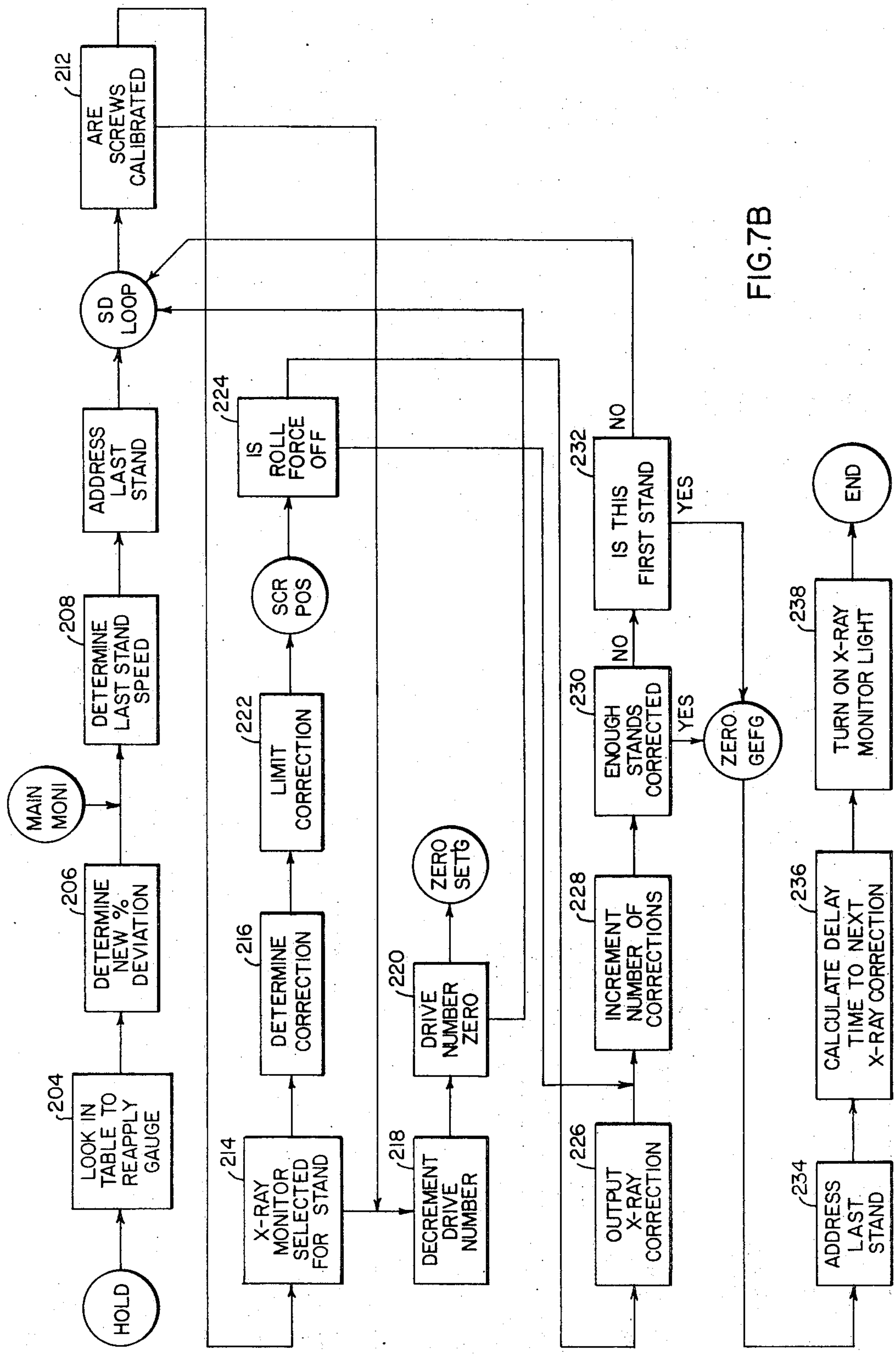
HOLD
204 LOOK IN TABLE TO REAPPLY GAUGE
206 DETERMINE NEW % DEVIATION
MAIN MONI
208 DETERMINE LAST STAND SPEED
ADDRESS LAST STAND
SD LOOP
212 ARE SCREWS CALIBRATED
214 X-RAY MONITOR SELECTED FOR STAND
216 DETERMINE CORRECTION
222 LIMIT CORRECTION
SCR POS
224 IS ROLL FORCE OFF
218 DECREMENT DRIVE NUMBER
220 DRIVE NUMBER ZERO
ZERO SETG
226 OUTPUT X-RAY CORRECTION
228 INCREMENT NUMBER OF CORRECTIONS
230 ENOUGH STANDS CORRECTED
YES
NO
ZERO GEFG
232 IS THIS FIRST STAND
YES
NO
234 ADDRESS LAST STAND
236 CALCULATE DELAY TIME TO NEXT X-RAY CORRECTION
238 TURN ON X-RAY MONITOR LIGHT
END

FIG.7B

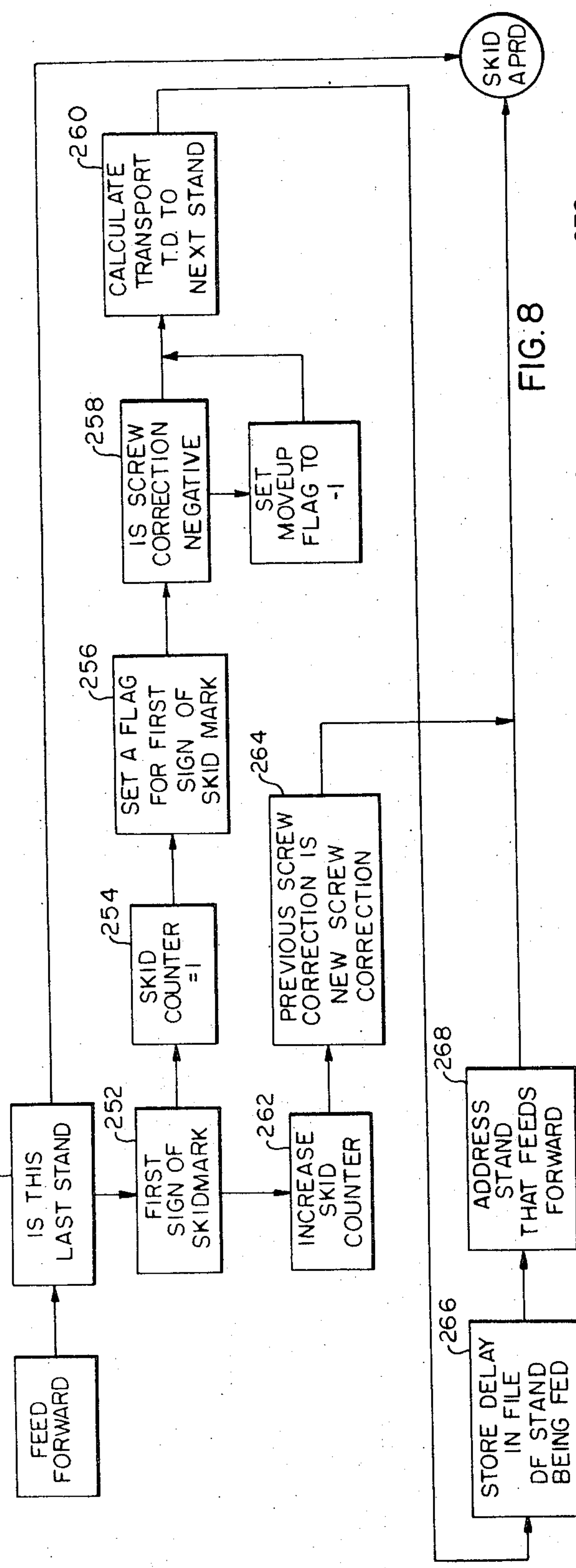
FEED FORWARD
250
IS THIS LAST STAND
252
FIRST SIGN OF SKIDMARK
254
SKID COUNTER =1
256
SET A FLAG FOR FIRST SIGN OF SKID MARK
258
IS SCREW CORRECTION NEGATIVE
SET MOVEUP FLAG TO -1
260
CALCULATE TRANSPORT T.D. TO NEXT STAND
SKID APRD
262
INCREASE SKID COUNTER
264
PREVIOUS SCREW CORRECTION IS NEW SCREW CORRECTION
266
STORE DELAY IN FILE OF STAND BEING FED
268
ADDRESS STAND THAT FEEDS FORWARD

FIG. 8

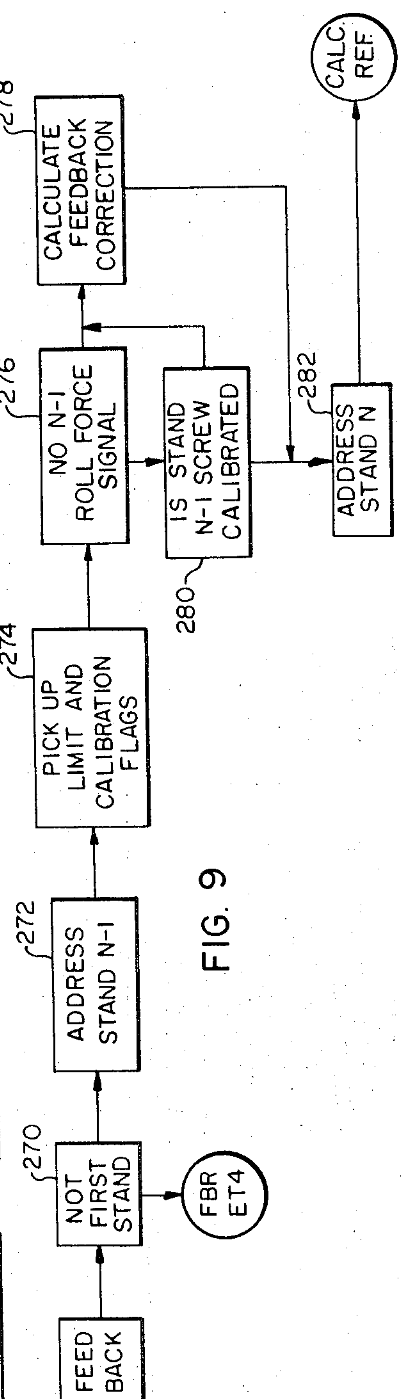
FEED BACK
270
NOT FIRST STAND
FBR ET4
272
ADDRESS STAND N-1
274
PICK UP LIMIT AND CALIBRATION FLAGS
276
NO N-1 ROLL FORCE SIGNAL
278
CALCULATE FEEDBACK CORRECTION
280
IS STAND N-1 SCREW CALIBRATED
282
ADDRESS STAND N
CALC. REF.

FIG. 9

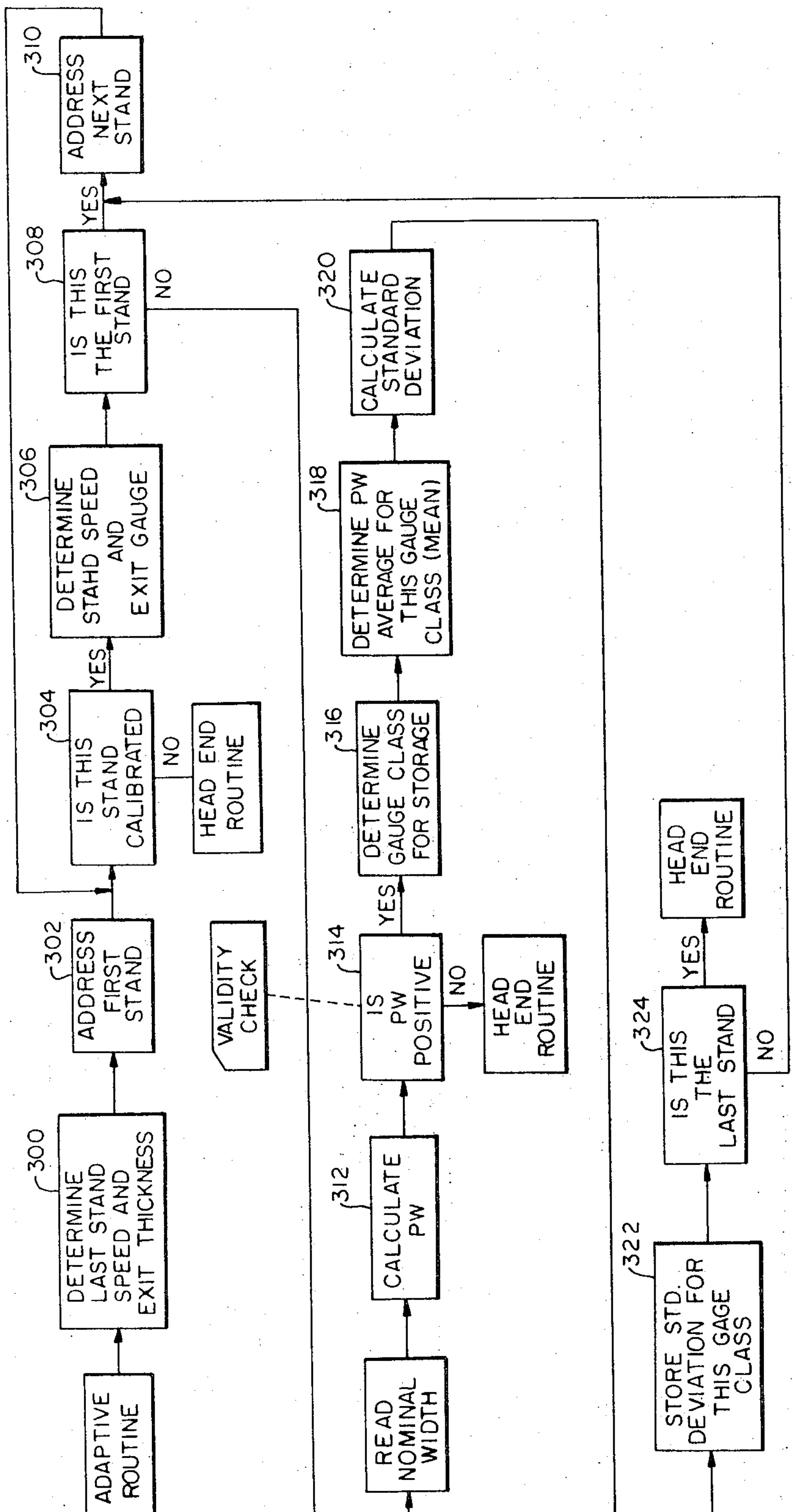
ADAPTIVE ROUTINE
DETERMINE LAST STAND SPEED AND EXIT THICKNESS
300
ADDRESS FIRST STAND
302
IS THIS STAND CALIBRATED
304
NO
YES
HEAD END ROUTINE
DETERMINE STAHD SPEED AND EXIT GAUGE
306
IS THIS THE FIRST STAND
308
YES
NO
ADDRESS NEXT STAND
310
READ NOMINAL WIDTH
CALCULATE PW
312
IS PW POSITIVE
314
NO
YES
VALIDITY CHECK
HEAD END ROUTINE
DETERMINE GAUGE CLASS FOR STORAGE
316
DETERMINE PW AVERAGE FOR THIS GAUGE CLASS (MEAN)
318
CALCULATE STANDARD DEVIATION
320
STORE STD. DEVIATION FOR THIS GAGE CLASS
322
IS THIS THE LAST STAND
324
YES
NO
HEAD END ROUTINE

FIG. 10

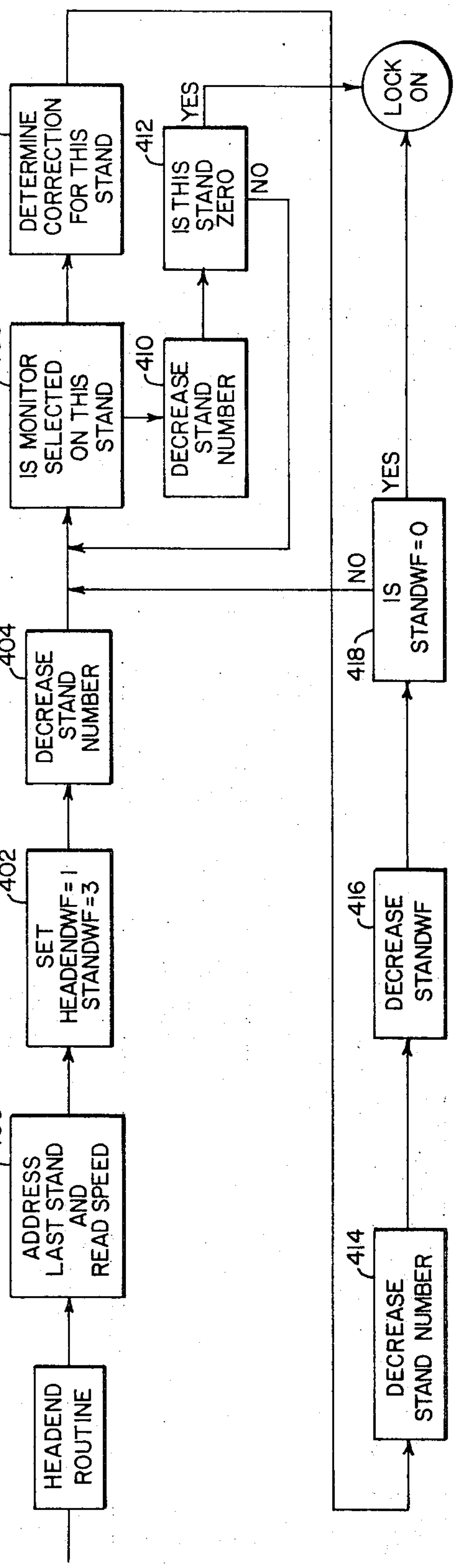
HEADEND ROUTINE
400
ADDRESS LAST STAND AND READ SPEED
402
SET HEADENDWF=1 STANDWF=3
404
DECREASE STAND NUMBER
406
IS MONITOR SELECTED ON THIS STAND
408
DETERMINE CORRECTION FOR THIS STAND
410
DECREASE STAND NUMBER
412
IS THIS STAND ZERO
YES
NO
LOCK ON
414
DECREASE STAND NUMBER
416
DECREASE STANDWF
418
IS STANDWF=0
YES
NO

FIG.11

GAUGE CONTROL METHOD AND APPARATUS INCLUDING WORKPIECE GAUGE DEVIATION CORRECTION FOR METAL ROLLING MILLS

CROSS REFERENCE TO RELATED APPLICATIONS

Reference is made to the following concurrently filed and related patent applications which are assigned to the present assignee:

S.N. 215,747, filed Jan. 6, 1972, entitled Gauge Control Method And Apparatus Including Workpiece Plasticity Determination For Metal Rolling Mills and filed by A. W. Smith and R. Q. Fox.

S.N. 215,743, filed Jan. 6, 1972, entitled Gauge Control Method And Apparatus For Metal Rolling Mills and filed by A. W. Smith and R. Q. Fox.

BACKGROUND OF THE INVENTION

The present invention relates to workpiece strip metal tandem rolling mills and more particularly to roll force gauge control systems and methods used in operating such rolling mills.

In the operation of a metal or steel reversing or tandem rolling mill, the unloaded roll opening and the speed at each tandem mill stand or for each reversing mill pass are set up by the operator to produce successive workpiece (strip or plate) reductions resulting in work product at the desired gauge. Generally, the loaded roll opening at a stand equals the stand delivery gauge on the basis of the usually justifiable assumption that there is little or no elastic workpiece recovery.

Since the operator provided initial setup conditions or the initial roll opening settings provided by an associated computer control system operative with model equation information to calculate the setup screwdown schedules for the rolling mill, can be in error and since in any event certain mill parameters affect the stand loaded roll opening during rolling and after setup conditions have been established, a stand automatic gauge control system must be employed if it is necessary that the stand delivery gauge be closely controlled. Thus, at the present state of the rolling mill art and particularly the steel rolling mill art, a stand gauge control system is normally used for a reversing mill stand and for predetermined stands in tandem rolling mills.

More particularly, the well known gaugemeter or roll force system has been widely used to produce stand gauge control in metal rolling mills and particularly in tandem hot steel strip rolling mills and reversing plate mills where experience has demonstrated that roll force control is particularly effective. Earlier publications and patents such as an article entitled Installation and Operating Experience with Computer and Programmed Mill Controls by M. D. McMahon and M. A. Davis in the 1963 Iron and Steel Engineer Year Book at pages 726 to 733, an article entitled Automatic Gage Control for Modern Hot Strip Mills by J. W. Wallace in the December 1967 Iron and Steel Engineer at pages 75 to 86, U.S. Pat. No. 3,561,237 issued Feb. 9, 1971 to Eggers et al, and U.S. Pat. No. 2,726,541, issued Dec. 13, 1955 to R. B. Sims describe the theory upon which operation of the roll force and related gauge control systems is based. Attention is also called to U.S. Pat. No. 3,568,637 issued Mar. 9, 1971, U.S. Pat. Nos. 3,574,279 and 3,574,280 issued Apr. 13, 1971, and U.S. Pat. No. 3,600,920 issued Aug. 24, 1971 to A. W. SMith, which relate to roll force automatic gauge control systems. In referencing prior art publications or patents as background herein, no representation is made that the cited subject matter is the best prior art.

Briefly, the roll force gauge control system uses Hook's law in controlling the screwdown position at a rolling stand, i.e., the loaded roll opening under workpiece rolling conditions equals the unloaded roll opening or screwdown position plus the mill spring stretch caused by the separating force applied to the rolls by the workpiece. To embody this rolling principle in the roll force gauge control system, a load cell or other force detector measures the roll separating force at each controlled roll stand and the screwdown position is controlled to balance roll force changes from a reference value and thereby hold the loaded roll opening at a substantially constant value. The following well known formula expresses the basic roll force gauge control relationship:

$$h = So + F \cdot K \tag{1}$$

where:

h = loaded roll opening (workpiece delivery gauge or thickness)

So = unloaded roll opening (screwdown position)

K = mill spring constant

F = roll separating force.

Typically, the roll force gauge control system is an analog arrangement including analog comparison and amplification circuitry which responds to roll force and screwdown position signals to control the screwdown position and hold the following equality:

$$\Delta S = -\Delta F \cdot K \tag{2}$$

where:

ΔF = measured change in roll force from an initial force

ΔS = controlled change in screwdown position from an initial screwdown position.

After the unloaded roll opening setup and the stand speed setup are determined by the mill operator for a particular workpiece pass or series of passes, the rolling operation is begun and the screwdowns are controlled to regulate the workpiece delivery gauge from the reversing mill stand or from each roll force controlled tandem mill stand. By satisfying Equation (2), and the assumptions implicit in Equation (1), the loaded roll opening h in Equation (1) is maintained constant or nearly constant.

As the head end of the workpiece strip enters each roll stand of the mill, the lock-on screwdown position and the lock-on roll separating force are measured to establish what strip gauge should be maintained out of that roll stand. As the strip rolling operation proceeds, the roll stand separating force and the roll stand screwdown position values are monitored and any undesired change in roll separating force is detected and compensated for by a corresponding correction change in screwdown position. The lock-on gauge LOG is equal to the lock-on screwdown LOSD plus the lock-on force LOF multiplied by the mill stand spring modulus K. The workpiece strip delivery gauge G leaving the roll stand at any time during the rolling operation is in accordance with above equation (1) and is equal to the unloaded screwdown position SD plus the roll separating force F multiplied by the mill spring modulus K.

The gauge error is derived by subtracting the lock-on guage from the delivery gauge. The following Equations 3, 4 and 5 set forth these relationships.

$$LOG = LOSD + K*LOF \qquad (3)$$

$$G = SD + K*F \qquad (4)$$

$$G - LOG = GAUGE\ ERROR = [SD - LOSD] + [(F-LOF)*K] \qquad (5)$$

One mill condition which can cause steady state gague error is an incorrect operator setup. Thus, the screwdown position and the stand speed setup at a particular stand results in a head end stand delivery gauge which may or may not equal the head end gauge desired from the setup values. If the roll force control uses a head end lock on roll force reference, the stand is roll force controlled to continue rolling the actual head end gauge unless the screwdowns are externally offset to produce the correct steady state gauge.

The initial screwdown position calibration is a direct electromechanical measurement technique made at the beginning of work roll life and if desired new "initial" calibrations are made at various subsequent time points in the work roll life. In any case, the predetermined initial screwdown calibration is subject to change during mill operation and any such change requires screwdown offset for correction of the roll force control operation. Typically, calibration drift is caused by changes in roll stand heating, stand speed (bearing oil film thickness), roll wear, differential leveling operation of the screwdowns for shape control and possibly by changes in other mill conditions.

When the initial screwdown calibration does drift, changes occur in the screwdown position at which roll facing occurs thereby making the unloaded roll opening correspondence with screwdown position differ from the initial correspondence by the amount of the calibration drift. As a result, the actual loaded roll opening, i.e. the actual gauge, differs from the expected value calculated with the use of an unloaded roll opening which is based on the erroneous calibration. The difference represents a gauge error condition which is correctable by a screwdown offset or, more specifically, a screwdown recalibration. If the mill spring constant changes, the actual loaded roll opening differs from the expected value calculated with the use of a mill stretch which is based on the erroneous mill spring constant, and the resultant gauge error condition is normally similarly correctable by a screwdown offset.

To provide steady state gauge error correction, the well known monitor gauge control system is usually employed to produce screwdown offset for the roll force controls. In the monitor system, an X-ray or other radiation gauge is placed at one or more predetermined process points and usually at least at a process point following the delivery end of the mill in order to sense actual delivery gauge after a workpiece transport delay from the point in time at which the actual delivery gauge is produced at the preceding stand or stands. The monitor system compares the actual delivery gauge with the desired delivery gauge and develops an analog feedback control signal to adjust the operation of the reversing mill roll force gauge control system or one or more predetermined tandem mill stand roll force gauge control systems to supply desired steady state mill delivery gauge. In this manner, the conventional monitor system provides for transport delayed correction of steady state gauge errors which are caused or which are tending to be caused by a single mill variable or by a combination of mill variables.

In operator controlled mills, some steady state gauge correcting load can eventually be taken off the monitor system by screwdown recalibration, and the like, between workpiece passes if steady state gauge error tends to exist along the entire workpiece and persists from workpiece to workpiece. In this manner, some reduction is achieved in the length of off gauge workpiece material otherwise associated with monitor transport delay. Similarly, corrective monitor system operation caused by head end gauge errors can be reduced by changes in the operator or associated computer control system provided setup from workpiece to workpiece.

A background teaching of stored program digital computer system operation can be found in a book entitled Electronic Digital Systems by R. K. Richards and published in 1966 by John Wiley and Sons.

A more detailed description of computer programming techniques in relation to the control of metal rolling mills can be found in an article in the Iron and Steel Engineer Yearbook for 1966 at pages 328 through 334 entitled "Computer Program Organization for an Automatically Controlled Rolling Mill" by John S. Deliyannides and A. H. Green, and in another article in the Westinghouse Engineer for January 1965 at pages 13 through 19 and entitled "Programming for Process Control" by P. E. Lego.

SUMMARY OF THE INVENTION

In accordance with the broad principles of the present invention, a system and method for controlling gauge in a metal rolling mill employs means for detecting at least one error condition representing gauge error and means for controlling screwdown position at each of one or more predetermined rolling stands of the mill. Means are also provided for determining the total amount of screwdown movement (position change) required to correct the error condition at predetermined mill spring constant and workpiece plasticity values. In roll force gauge control, the roll force is detected and the determined error conditions is a gauge error.

There is calculated a correction in relation to a gauge error or X-ray gauge deviation measured after the last roll stand which correction is for selected roll stands previous to the last roll stand. This calculated correction is determined from the rolling of an initial workpiece strip for adjusting the roll opening settings of the selected roll stands before the subsequent rolling of another workpiece strip similar to that initial workpiece strip. A selected number of previous roll stands are corrected while the last stand is roll force gauge controlled. This correction is determined by a mass flow relationship with the speed of the last stand and the speed of the corrected stand, the measured gauge deviation and a predetermined weighting factor.

A digital computer system is preferably employed to make the error correction screwdown movement determinations as well as to perform other mill control functions. The computer employs a programming system including an automatic roll force gauge control program or AGC program which is executed at predetermined intervals to calculate the desired screwdown movement required at each roll force gauge controlled stand for gauge error correction including that stemming from roll force error detection at that stand. Screwdown movement for correcting roll force error is made on the basis of calculations which use selected workpiece plasticity and mill spring constant values stored in data tables in the computer system memory or otherwise determined by the computer system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram of a tandem hot steel strip rolling mill and a digital computer system automatic gauge control therefor arranged for operation in accordance with the principles of the invention;

FIG. 2 illustrates a mill spring curve and a workpiece reduction curve for a given rolling mill stand and the manner in which roll force screwdown correction is determined in relation to a change in the stand load force;

FIG. 3 illustrates a mill spring cruve and a workpiece reduction curve for a given rolling mill stand and the manner in which roll force screwdown correction is determined in relation to a change in both the stand load force and the stand screwdown position setting;

FIG. 4 shows an illustrative mill stand deflection curve and product deformation curve to show the required screw movement to correct a determined gauge error;

FIG. 5 shows a graphic representation of typical PW plasticity values, such as could be included in the use table as loaded into the computer control system memory or such as could be included in the adaptive table.

FIGS. 6A, 6B and 6C show an illustrative logic flow chart of an AGC program operative with a tandem hot strip rolling mill;

FIGS. 7A and 7B show an illustrative logic flow chart of an X-ray routine program operative with the AGC program shown in FIGS. 6A, 6B and 6C;

FIG. 8 shows an illustrative logic flow chart of a feed forward routine program operative with the above AGC program shown in FIGS. 6A, 6B and 6C;

FIG. 9 shows an illustrative logic flow chart of a feedback routine program operative with the AGC program shown in FIGS. 6A, 6B and 6C;

FIG. 10 shows an illustrative logic flow chart of the adaptive routine program operative with the X-ray routine program shown in FIGS. 7A and 7B; and

FIG. 11 shows an illustrative logic flow chart of the head end routine program operative with the X-ray routine program shown in FIGS. 7A and 7B.

GENERAL DESCRIPTION OF THE AUTOMATIC GAUGE CONTROL SYSTEM AND ITS OPERATION

There is shown in FIG. 1 a tandem hot strip steel finishing mill 11 operated with improved gauge control performance by a process control system 13 in accordance with the principles of the invention. Generally, however, the invention is applicable to various types of mills in which roll force gauge control is employed. Thus, the invention can be suitably adapted for application in hot steel plate reversing and other rolling mills.

The tandem mill 11 includes a series of reduction rolling stands with only two of the stands S1 and S6 shown. A workpiece 15 enters the mill 11 at the entry end in the form of a bar and it is elongated as it is transported through the successive stands to the delivery end of the mill where it is coiled as a strip on a downcoiler 17. The entry bar would be of known steel grade and it typically would have a thickness of about 1 inch and a width within some limited range such as 20 inches to 80 inches. The delivered strip would usually have approximately the same width and a thickness based upon the production order for which it is intended.

In the reduction rolling process, the successive stands operate at successively higher speeds to maintain proper workpiece mass flow. Each stand produces a predetermined reduction or draft such that the total mill draft reduces the entry bar to strip with the desired gauge or thickness.

Each stand is conventionally provided with a pair of backup rolls 19 and 21 and a pair of work rolls 23 and 25 between which the workpiece 15 is passed. A large DC drive motor 27 is controllably energized at each stand to drive the corresponding work rolls at a controlled speed.

As previously described, the sum of the unloaded work roll opening and the mill stretch substantially defines the workpiece gauge delivered from any particular stand in accordance with Hooke's law. To vary the unloaded work roll opening at each stand, a pair of screwdown motors 29 (only one shown at each stand) position respective screwdowns 31 (only one shown at each stand) which clamp against opposite ends of the backup rolls and thereby apply pressure to the work rolls. Normally, the two screwdowns 31 at a particular stand would be in identical positions, but they can be located in different positions for strip guidance during threading, for flatness or other strip shape control purposes or possibly for other purposes.

A conventional screwdown position detector or encoder provides an electrical representation of screwdown position at each srand. To provide an absolute correspondence between the screwdown position and the unloaded roll opening between the associated work rolls, a screwdown position detection system which includes the screwdown position detector 33 can be calibrated from time to time in the manner previously described.

Roll force detection is provided at each of predetermined stands by a conventional load cell 35 which generates an electrical analog signal. At the very least, each roll force controlled stand is provided with a load cell 35 and in many cases stands without roll force gauge control would also be equipped with load cells. The number of stands to which roll force gauge control is applied is predetermined during the mill design in accordance with cost-performance standards, and increasingly there is a tendency to apply roll force gauge control to all of the stands in a tandem hot strip steel mill. In the present case, a roll force gauge control system is assumed to be employed at each of the stands.

Conventional motorized sideguards 37 are located at predetermined points along the mill length. The sideguards 37 are operated during mill setup on the basis of the widths of the upcoming workpiece 15 thereby defining the sides of the workpiece travel path for guidance purposes.

The process control system **13** provides automatic control for the operation of the tandem mill **11** as well as may be desired for associated production processes (not indicated) such as the operation of a roughing mill. Preferably, the process control system **13** comprises a programmed process control digital computer system **39** which is interfaced with the varoius mill sensors and the various mill control devices to provide control over many of the various functions involved in operating the tandem mill **11.** According to user preference, the control system **13** can also include conventional manual and/or automatic analog controls for backup operation in performing preselected mill functions.

On the basis of these considerations, the digital computer system **39** includes a finishing mill on-line roll force gauge control computer system, such as a Prodac 2000 (P2000) sold by Westinghouse Electric Corporation. A descriptive book entitled Prodac 2000 Computer Systems Reference Manual has been published in 1970 by Westinghouse Electric Corporation and made available for the purpose of describing in greater detail this computer system and its operation.

The computer processor is associated with well known predetermined input systems typically including a conventional contact closure input system which scans contact or other signals representing the status of various process conditions, a conventional analog input system which scans and converts process analog signals, and operator controlled and other information input devices and systems **41** such as paper tape teletypewriter and dial input systems. It is noted that the information input devices **41** are generally indicated by a single block in FIG. **1** although different input devices can and typically would be associated with the computer system **39.** Various kinds of information are entered into the computer system **39** through the input devices **41** including, for example, desired strip delivery gauge and temperature, strip entry gauge and width and temperature (by entry detectors if desired), grade of steel being rolled, plasticity tables, hardware oriented programs and control programs for the programming system, and so forth.

The contact closure input systems and the analog input systems interface the computer system **39** with the processes through the medium of measured or detected variables. The present invention is largely involved in the functioning of the automatic gauge control computer system, hereinafter referred to as the AGC computer. In one typical invention application, various mill signals are applied to the AGC computer input systems. These mill signals include the following:

1. A roll force signal from the load cell **35** at each stand proportional to stand roll separating force for use in roll force gauge control.

2. Screwdown position signals generated by the respective detectors **33** at the stands for use in roll force gauge control.

3 Screwdown motor speed signals generated by respective tachometers **49** at the stands for use in programmed regulation.

4 Stand speed signals generated by respective tachometers **43,** with the speed signal used for calculation of acceleration compensation and for calculation of time delays in monitor operation.

5 A gauge deviation signal from an X-ray gauge **47** at the delivery end of the mill for programmed monitor gauge control through the roll force control.

6 An entry temperature signal from a mill entry temperature detector or pyrometer **45**; the mill entry temperature for the head end of each workpiece **15** is stored.

7 Width signals supplied by sideguard follow potentiometers for mill spring constant calculations, etc.

It is noted at this point in the description, that the measured head end roll force is stored and used as a reference for roll force gauge control functioning at the respective stands if the AGC computer is in the lock-on mode of roll force operation.

A contact closure output system would normally be associated with the digital computer system **39.** In the operation of the AGC contact closure output system, various control devices are operated in response to control actions calculated or determined by execution of control programs in the AGC computer.

To effect determined control actions, controlled devices are operated directly by means of output system contact closures or by means of analog signals derived from output system contact closures through a digital to analog converter. The principal control action outputs from the AGC computer contact closure output system include screwdown positioning commands which are applied to respective screwdown positioning controls **55** in operating the screwdown motors **29** for screw movement, and speed control signals which are applied to the respective speed and tension control system **53** to cause a change in drive speed to compensate the force on the strip for a change in thickness being made by a screwdown movement.

Display and printout systems **51** such as numeral display, tape punch, and teletypewriter systems are also associated with the outputs of the digital computer system **39** in order to keep the mill operator generally informed about the mill operation and in order to signal the operator regarding an event or alarm condition which may require some action on his part. The printout systems are also used to log mill data according to computer log program direction.

Generally, the AGC computer uses Hooke's law to determine the total amount of screwdown movement required at each roll force controlled stand at the calculating point in time for roll force and gauge error correction, i.e., for loaded roll opening and stand delivery gauge correction to the desired value. The calculation defines the total change in the unloaded roll opening required to offset a new mill stretch value or other roll force and gauge error causing condition. The predicted corrective screwdown position change value is employed in a screwdown position control program in the AGC computer to define the screwdown motor position-time profile to be followed in making the corrective screwdown movement.

During rolling operation, the on line gauge control system operates the stands to produce strip product having desired gauge and proper shape, i.e., flat with slight crown. On line gauge control is produced by the roll force gauge control loops at the stands and the previously noted screwdown monitor gauge control system.

In the monitor system, the X-ray gauge **47** produces the previously indicated X-ray deviation signal which indicates the difference between actual strip delivery thickness and desired or target strip delivery thickness. In other cases, it may be desirable to employ an absolute thickness measurement X-ray gauge signal to form a basis for monitor control actions or, more generally, for screwdown offset control actions.

To effect on line gauge control in the closed loops, the programmed AGC computer system operates on the screwdown position detector and load cell signals from each stand as well as the X-ray gauge deviation signal to determine the control actions required for producing desired strip delivery gauge. Screwdown motor speed is in this instance also applied to the computer system **39** in order to provide for programmed screwdown positioning control. In effecting control operations, the AGC computer employs an AGC programming system which forms a part of the total programming system for the computer system **39.** The AGC programming system includes programs oriented to controlling the AGC computer system hardware and programs oriented to developing the control actions.

In FIG. **2,** curves are shown to illustrate the application of Hooke's law to a rolling mill stand and to illustrate the unique basis upon which the process control system **13** and in particular the on line AGC computer gauge control system provides improved gauge control speed, accuracy and stability and other operating benefits. A mill spring curve defines the separation between a pair of mill stand work rolls as a function of separating force and as a function of screwdown position. The slope of the mill spring curve is the well known mill spring constant K which is subject to variation as previously described. When a correct screwdown calibration is known and the screwdowns are positioned such that the empty work rolls are just facing, the unloaded screwdown zero position is defined. The zero screwdown location mill spring curve is indicated by the reference character **61.**

At the correct calibration condition, the indicated theoretical face intersect represents theoretical roll facing and it is for this theoretical condition that the screwdown position is assigned to a zero value. Under the correct calibration condition, roll facing actually occurs when the screwdown position is at a slightly negative value because of the nonlinearity of the lower part of the mill spring curve. A definition of the screwdown calibration as being correct for the indicated theoretical condition is, however, convenient and appropriate for mill operation.

When the screwdowns are opened (positive movement) the unloaded roll opening increases as reflected by a change to the right in the graphical location of the mill spring curve as indicated generally by crve **67** such that the theoretical spring curve intersect equals the new unloaded roll opening. With screwdown closing, the mill spring curve is shifted to the left in a similar manner.

At any particular screwdown position and with correct screwdown calibration, the stand workpiece delivery gauge equals the unloaded roll opening as defined by the screwdown position S_{Io} plus the mill stretch caused by the workpiece. If the screwdown calibration is incorrect, i.e., if the number assigned to the theoretical roll facing screwdown position is something other than zero because of roll crown wear or other causes, the stand workpiece delivery gauge equals the unloaded roll opening plus the mill stretch plus or minus the calibration drift.

The amount of mill stretch depends on the characteristic reduction curve for the workpiece. As shown in FIG. **2,** a reduction curve **65,** for a strip of predetermined width represents the amount of force required to reduce the workpiece from a stand entry thickness (height) of H_{IN}. The workpiece plasticity P is the slope of the curve **65,** and in this case the curve **65** is shown as being linear although a small amount of nonlinearity would normally exist.

Desired workpiece gauge H_D is the initial condition IC produced in this case since the amount of force required to reduce the workpiece from H_{IN} to H_D is equal to the amount of roll separating force required to stretch the rolls to a loaded roll opening H_D, i.e., the intersection of the mill spring curve at an initial screwdown opening S_{IO} indicated by mill spring curve **67** and the workpiece reduction curve **65** lies at the desired gauge value.

As shown in FIG. **2,** if the stand delivery gauge increases by a gauge error amount GE to H_X during a workpiece pass to produce a present condition PC, in this instance because the workpiece plasticity decreases and because the workpiece entry thickness increases to H_{XIN} as represented by the reduction curve **69,** the stand screwdowns must be closed to a value which causes a future correct gauge condition FC. At the condition FC, the intersection of the mill spring curve and the new reduction curve **69** lies at the desired gauge H_D as provided by a spring curve location indicated by the reference character **63.** In other words, corrective screwdown closing causes the unloaded screw opening to be reduced by an amount ΔS_{RF} to a new value which adds with the new mill stretch to equal the desired gauge H_D.

As shown in FIG. **3,** after the stand screwdowns are moved from the initial position S_{IO} to another position S_o, the force error FE and the related gauge error GE must not only take into consideration the change in force from the initial value F_R but also the change in screwdown from the initial position S_{IO}. The correction required in the screwdown position is ΔS_{RF} to produce the desired gauge H_D, and the new screwdown position S_o' is

$$S_o' = S_o - \Delta S_{RF} \tag{6}$$

where:

S_o is the present unloaded screwdown position

ΔS_{RF} is the required correction in the screwdown position.

In accordance with the present invention, ΔS_{RF} is calculated to enable roll force gauge control operation in accordance with the following programmed algorithm:

$$\Delta S_{RF} = [K/P + 1] * GE \tag{7}$$

ΔS_{RF} = required screwdown correction

where:

GE = gauge error

K = mill spring constant (in/10^6lb)

P = workpiece plasticity (in/10^6lb)

Equation 7 is derived with reference to FIG. 3 as follows:

$$GE = FE \cdot K = \text{gauge error} \quad (8)$$

$\Delta F = GE/P$ = expected change in roll force resulting from corrective screwdown movement. (9)

$$\Delta S_{RF} = \Delta F \cdot K + \Delta F \cdot P = \Delta F * [K+P] \quad (10)$$

$$\Delta S_{RF} = GE/P * [K+P] = GE * [K/P + 1] \quad (11)$$

In order to calculate the predicted amount of screwdown movement required to correct a gauge error, the gauge error GE is calculated as follows:

$$GE = [F_X - F_R] \cdot K + (S_o - S_{IO}) \quad (12)$$

In providing for the gauge error calculations Equation **12** defines the difference between the present roll force F_X and the reference roll force F_R (either lock on or absolute as predetermined) in relation to the stand mill spring constant and subtracts from that difference the amount of change in roll force caused by screwdown movement made to correct previous roll force error. For the condition PC shown in FIG. **2**, $S_o = S_{IO}$ in Equation 12, but in general S_o would typically have some value other than S_{IO} as shown in FIG. **3.**

Corrective screwdown movement in the predicted amount produces further roll force change and FE becomes zero if the system behavior corresponds to predictions and if no new roll force error develops during the period of correction. If the system does not behave as predicted, FE does not become zero and in effect a new roll force error PE is generated to the extent that the executed screwdown movement in the predicted amount fails to correct the stand delivery gauge.

It is also noted at this point in the description that the screwdown reference S_{IO} used as a base for determining the gauge error GE in Equation 12 is updated as follows:

$$S_{IO}\,(\text{new}) = S_{IO} - S_M + S_{RFP} \quad (13)$$

where:

S_M = Screwdown offset produced by conventional X-ray monitor operation

S_{RFP} = screwdown offset produced for roll force error anticipated by feedforward action.

These quantities are considered more fully in the disclosure of the above referenced U.S. Pat. No. 3,561,237. By way of explanation, the screwdown reference S_{IO} can be up-dated in accordance with Equation **13** as changes occur in S_M and S_{RFP} in order to prevent the stand roll force gauge control system from responding to roll force changes caused solely by screwdown movement required by external screwdown offset system control for screwdown calibration, head end gauge error correction in the lock on mode of operation, anticipatory mill speed change compensation, anticipatory roll force error compensation or other gauge error correcting purposes. If conventional X-ray monitor is not employed in the system **13,** the corresponding term S_M can be omitted from Equation 13.

Generally the operative value of each stand spring constant K is relatively accurately known. It is first determined by the conventional work roll screwdown test, and it is recalculated prior to each workpiece pass on the basis of the workpiece width and the backup roll diameter. Each resultant spring curve **61** is stored for on line gauge control use.

The form in which the spring constant K is stored can vary. In the present case, the slope of the linear part of the spring curve is stored as a single value. The nonlinear part of the spring curve is estimated by three straight lines of increasing slope with the respective slopes stored as three separate spring constant values which are corresponding force range. As future mill data returns from computer data logging demonstrate presently unknown relationships which may define on line variations of the mill spring constant as a function of certain mill variables, provision can be made for programming on line calculations of the mill spring constant in accordance with such relationships under dynamic mill operating conditions.

The operative value of the workpiece plasticity P at each stand is also relatively accurately determined. In the present case, P tables are stored in the computer system **39** to identify the various values of P which apply to the various mill stands for various grade class and gauge class workpieces under various operating conditions and at various operating times during the rolling of the strip **14.** The plasticity values are stored in the table as a plasticity for a product with a width of unity, typically in inches/10^6 pounds/in wide. The values in the table, PW, are divided by the width of the product being rolled to obtain the appropriate value.

Hot strip mill gauge control using programmed digital computer evaluation of the roll force feedback information involves the combination of a number of process control operations. Roll force, screw position, and mill spring information is used to evaluate the gauge of the strip as it is worked in each stand, and an X-ray gauge is used on the strip as it passes out of the last stand to evaluate the absolute strip gauge produced by the rolling mill.

A multi-stand and continuous hot strip mill requires a gauge control system to maintain uniform gauge. Typically a hot strip mill will roll a single strip simultaneously in all of its stands. Therefore the gauge control system used with the mill should be able to determine gauge errors leaving each of the stands as quickly as possible, and it should be able to make corrections to those gauge errors in as many stands as may be necessary.

There are two gauge error detection systems used for this purpose to consider: (1) X-ray and (2) roll force. X-ray gauge measuring devices should be placed after each roll stand; they are accurate, but they are expensive, difficult to maintain, and can only detect errors after the workpiece strip has passed the provided distance between the associated roll stand and the subsequent gauge measuring X-ray device. On the other hand, the roll force gauge error detection system is much less expensive, and can be more easily implemented in all roll stands; it detects errors in the workpiece strip gauge as the strip is still passing between the rolls, thereby allowing more immediate evaluation of required corrections to the roll stand screwdown position setting. Unfortunately, the roll force system provides only a relative evaluation of the strip gauge, since it measures how much the strip gauge has deviated from the gauge of the head end portion of the strip.

A practical combination of the above two gauge error detection systems is to use roll force feedback information to calculate fast desired corrections to errors in strip gauge, and to use one X-ray gauge measuring device after the last roll stand to evaluate the absolute gauge of the strip coming out of the last stand. The fast corrections are calculated from the roll force feedback information, combined with the detected stand screwdown position and the predetermined modulus of elasticity of the rolling stand. The slower X-ray device gauge error evaluation is used to calculate simultaneous monitor corrections to several stands so that the absolute value of the strip gauge leaving the rolling mill may be brought to the desired value. The output of each of these systems is a screwdown correction gauge in the respective positions of the screwdowns of each of the stands.

FIG. **2** shows the linear approximations of the mill deflection curve **67** and the product deformation curve **65** for a typical rolling mill stand operation. The unloaded roll opening S_{IO}, sometimes called the screwdown because of the screw and nut system used for adjusting the roll opening, is the strip gauge that would be delivered if there were no roll separating force. As the stand roll force increases with a constant roll opening, the delivery strip gauge increases, since the mill stand stretches or deflects. This is shown by the line **67** with slope K. The product deformation characteristic is represented by the line **65** with slope P. If there were no force exerted by the roll stand on the product being rolled, the strip gauge would not be reduced and the delivery strip gauge would be equal to the entry strip gauge. If the roll force is caused to increase, the product is plastically deformed and the delivery strip gauge decreases. The slope of the mill characteristic line **67** is called the mill spring modulus K, and the slope of the product deformation characteristic line **65** is called the product plasticity P.

The delivery strip gauge is determined by the equilibrium point IC where the force exerted by the mill stand is equal to the force required to deform the product. Changes in workpiece strip entry gauge and/or changes in product hardness result in a change in stand roll force and delivery strip gauge. The gauge error correcting control system must move the screwdown to correct for these resulting error changes in strip gauge.

The main advantage of using the roll force gauge control system is the ability to detect error changes in strip gauge the instant they take place as the product is being rolled in the roll stand. A shift in strip delivery gauge or thickness can be caused by a change in entry thickness, or a change in hardness as usually caused by a change in temperature. This change in delivery gauge can be immediately detected by feedback information monitoring of the roll separating force on the roll stand.

FIG. **3** illustrates the operation of a gauge error detection system, with the mill spring line **67** and product plasticity line **65** representing the initial lock-on condition of operation and the mill spring line **63** and plasticity line **69** representing the future condition. As compared to the original lock-on conditions, the screwdown system has moved in the closing direction and the roll separating force has increased because of a harder cold portion of the workpiece strip passing through the roll stand.

The required gauge error correction in screwdown position is not only dependent on the strip gauge error but also on the stand mill spring modulus and the product plasticity values. In FIG. **3** there is illustrated how the gauge error GE is removed by a screwdown correction ΔS_{RF}. The screwdown correction ΔS_{RF} is larger than and approximately twice the size of the gauge error GE, since this correction operation will actually result in an increase in stand roll force because of the greater reduction taken. Relatively soft workpiece strip products require a screw correction ΔS_{RF} very nearly the same as the gauge error GE but relatively hard products require a larger correction compared to the gauge error. The necessary screwdown movement ΔS_{RF} to correct a determined gauge error is determined as follows in relation to FIG. **4.** The screwdown correction ΔS_{RF} can be determined by the realtionship:

$$S_{RF} = X + GE \tag{14}$$

where:

X is the amount of roll opening change and hence strip delivery gauge change due to the stretch of the roll stand

GE is the gauge error.

The roll stand stretch X can be determined by the relationship:

$$X = K^* \Delta F \tag{15}$$

where: ΔF is shown in FIG. **4** and is the change in roll force when the gauge error GE is corrected.

From the illustration shown in FIG. **4,** it is also seen that

$$GE = P^* \Delta F \tag{16}$$

$$\Delta F = GE/P \tag{9}$$

now combining Equation 9 with Equation 15 will give

$$X = K^* (GE/P) \tag{17}$$

and combining Equation 17 with Equation 14 will give

$$\Delta S_{RF} = K^* (GE/P) + GE \tag{18}$$

$$\Delta S_{RF} = GE^* (K/P+1) \tag{11}$$

The screwdown correction ΔS_{RF} is shown in FIG. **4** in relation to the gauge error GE, the desired gauge H_D and the present gauge H_X.

FIG. **5** shows a graphic representation of typical PW values stored for a seven stand tandem hot strip mill. The six sets of values cover the range of thicknesses rolled from 0.050 inches to 0.250 inches. This could be an illustration of a use table as loaded by the operator into the computer storage memory or it could be an illustration of a learned table provided by the adaptive program.

The main roll force AGC program, as illustrated by the flowchart shown in FIG. **6,** and the associated X-ray monitor program, as illustrated by the flowchart shown in FIG. **7,** occupy the same task priority level, with both programs being initiated by the well known analog input signal scan operation. The roll force AGC program operationally maintains a constant workpiece gauge based on the initial mill setup parameters provided by the operator, while the X-ray program backs up the roll force AGC control by monitoring the final product gauge and making desired adaptive corrections as needed.

When a workpiece strip is being rolled, the roll force AGC program corrects deviations from the initial or head end exit gauge of each stand, by adjusting the screw opening of the stand. A deviation in the exit gauge of a stand from its initial or head end lock-on value is reflected in a sensed change in the roll force of the stand from its initial value. From the exit gauge error when scanned and determined every 2/10 second, a gauge error correction to the screw opening is determined and made by adjusting the screwdown position of the respective roll stand.

The main AGC program also includes a subroutine for making corrections to a stand's entry gauge by feeding back determined gauge error under specified conditions to the screw opening of the previous stand, this feedback program subroutine is illustrated by the flowchart shown in FIG. **8.** This feedback routine correction is normally made to the screwdown setting of a previous roll stand, when the screws for a given stand have reached a maximum or minimum limit and require further movement in a direction that would cause the limit to be exceeded, so a portion of the desired gauge error correction determined for that given stand is fed back to a previous stand such that the previous stand can help with this desired gauge error correction needed in relation to the operation of that given stand.

The flow charts shown in FIGS. **6, 7** and **8** are written in an effort to be substantially self-explanatory to persons skilled in this particular art, with the functions to be performed at each step of the flow charts being set forth accordingly.

In FIGS. **6**A, **6**B and **6**C there is shown a flow chart to illustrate a preferred embodiment of a suitable AGC program operative with a tandem hot strip rolling mill. At step **10** a determination is made to see if the automatic gauge control or AGC program has been selected and desired by the operator to be functional. The AGC program is run shortly after the head end of a workpiece strip has entered that stands of the rolling mill, and for each roll stand the initial lock-on roll force, lock-on speed and lock-on screwdown position setting is measured and saved in memory storage. At step **12** a determination is made to see if this particular scan is not an X-ran scan; for a typical rolling mill installation, there may be seven roll stands to be scanned plus a scan of the X-ray device located after the last roll stand in relation to the provision of analog input signals to be scanned by the digital computer system. This step **12** procedure relates to the organization of the analog signal inputs; if this is an X-ray input signal scan, the program goes to the X-ray subroutine at step **14,** and if this is not an X-ray scan and instead this is an AGC program run in relation to one of the drive stands the program goes to step **16** to determine if roll force has been selected by the operator for this stand, i.e., stand N, where N can be each one of the roll stands in sequence. Step **18** is provided to see if automatic scan has been selected by the operator for this stand. Each of steps **16** and **18** must be satisfied, or the program goes to step **20** for reset of a head end software flag and to step **22** for turn-off of the AGC light for that stand on the operator's control panel. The operator has a roll force select switch by which he initiates the roll force AGC program operation. At step **24** a determination is made to see if the screwdown positioning mechanisms for this stand have been calibrated. If they have, at step **26** the program checks to see that the workpiece strip is in this stand, and at step **28** to see if this is the first scan made on this particular strip. Each of these conditions has to be satisfied for the AGC program to run through for this stand as desired. For the first scan on this strip, the measured lock on force for this stand, the lock on speed and the lock on screwdown position is saved at step **30,** since these parameter values will be later needed for control purposes.

At step **32,** the measured lock on roll force for this stand is used with a predetermined look-up table of mill spring modulus values provided in storage, in relation to the well known nonlinear mill spring characteristic for a typical roll stand, to determine the value of the mill spring modulus K to use for subsequent calculations in relation to the lock on operation of this stand. It should be noted that the upper portion of the mill spring characteristic curve is well known by persons skilled in this art to be substantially linear as shown in FIGS. **2** and **3** above an initial lower portion for the typical roll stand and in accordance with the disclosure of U.S. Pat. No. 2,726,541 of R. B. Sims. At step **34** the stand mill spring modulus K is corrected in relation to the known width of the workpiece strip. At step **36** the exit gauge class for this stand is determined, such that at step **38** an adaptive learned look-up table operation will provide the average plasticity PW for this gauge class. At step **40** the plasticity constant P is calculated in relation to this determined average value PW divided by the known width of the workpiece strip. At step **42** the desired hardness correction in relation to known grade of the strip being rolled is determined by a predetermined table look-up operation with operator provided values of same. At step **44** the plasticity P for this stand is corrected for hardness.

At step **46** the stand screw position is read. It should be noted that if the present scan was not the first scan on this particular strip at step **28,** the program then went to step **46,** through NOT HEAD which is referenced in the program listing operative with the digital computer. At step **48,** if the stand load cell is ON, the strip gauge error is calculated at step **50** in accordance with above Equation **13.** At step **52** the desired screw position correction ΔS_{RF} is calculated in accordance with above equation **11.** At step **54** a check is made to see if the desired screw correction ΔS_{RF} is greater than an operator determined minimum response deadband value; if this screw correction is not greater than this deadband value, at step **56** it is made zero, and is this screw correction is greater than the deadband, at step **58** the running average gauge error is calculated. At step **60** if the screw correction is not within the operator defined maximum correction limits, the program advances to step **62** where the screw condition is set to equal that maximum correction limit and the feed forward subroutine is entered by step **64** to feed forward some of the needed gauge error correction from the stand to the later stands of the rolling mill. At step **66** a check is made to see if a feed forward correction from a previous stand is approaching this stand, such as would happen in relation to a skidmark. If it is, a determination is made at step **68** if the skidmark is about to enter the present stand. If a skidmark or like condition is approaching the present stand it is desired to begin the movement of the stand screwdown mechanism. At step **66**, if there was not a feed forward correction approaching this stand, there might have been such a correction already in the stand and the program then goes to step **70** to check if there is a skidmark in the present stand. If a skidmark is not in the stand and there is none approaching, the program goes to step **72** for the calculation of the new desired screwdown position for this stand. If there is a skidmark in this stand, and perhaps the stand screws hav already begun to move, the step **74** is provided to determine if this has happened. If it is the first check, the screws are told to take off in the desired direction at full speed at step **76** for the purpose of skidmark correction. At step **78** a check is made to see if the end of the skidmark has arrived at this stand, and if so the screw correction of-set is removed at step **80.** The counter is set in accordance with the known number of counts required to get the skidmark through this stand, and at step **81** if the skid counter is not zero the counter is decremented during each scan as required for the desired operation of the stand in relation to skidmark correction.

If there is not a skidmark in this stand at step **70**, the program goes to step **72** where a screw correction, such as ΔS_{RF} is to be calculated for this stand, and this calculation is made to see where the screws should be positioned to remove the gauge error at this stand. At step **82** a check is made to see if this new position will put the stand out of operator desired limits. If it will be out of limits at this stand, the excess screw movement will be fed back to an earlier stand at step **84** after setting a software flag at step **83.** If the new position is not out of limits at step **82,** a check is made at step **86** to see if the previous stand load cell is OFF and not operating. At step **88** the load cell of this stand is checked to see if it is operating. Now the screwdown position reference calculation is begun, and at step **90** a determination is made if the tail end of the workstrip has as yet dropped out of the previous stand. At step **92** a transport time delay is checked, and at step **94** if full compensation is desired then this compensation is added to the screw position at step **96.** Otherwise, partial compensation is made at step **98.** The program then goes to step **100** to calculate the actual new position of the screws for this stand. At step **102** the percentage change from the lock on screwdown position is calculated, and at step **104** a check is made to see if the calculated actual position is within operator provided screw positions limits for this stand. At step **106** the screw position movement for this stand is held within desired limits if necessary. At step **108** if the previous screw position for this stand was zero, an AGC indicating light for the operator is turned at step **110**; otherwise the direction of screw movement is determined at steps **112** and **114** with the looper going in respectively the opposite direction at steps **116** and **118.** At step **120** the position regulator for this stand is told to move the screw positioning drive as desired, and at step **122** the new screw position reference for this stand is saved in memory for subsequent operations. At step **124** if the workstrip is still in the previous stand, the program ends, otherwise a desired subroutine in preparation for the next workpiece strip and reset the stand screw positions in relation to the position of the tail end of the workpiece strip is performed at step **126.**

In relation to the X-ray routine at step **14** of the AGC program flow chart shown in FIG. **6**A, there is shown in FIGS. **7**A and **7**B a flow chart to illustrate the operation of this subroutine. At step **170** a check is made to see that the operator has selected the X-ray monitor operation. At step **172** a determination is made that the provided time delay for the next correction has expired, and at step **174** a check is made to see that a particular X-ray device is selected in the event that two X-ray devices are provided after the last stand. At step **176** a determination is made that the X-ray device is measuring strip gauge. If any one of the dterminations at steps **170, 172, 174** an **176** is negative then the program exits. At step **178** the operator desired target or nominal workpiece strip gauge is read from storage. It should be understood that gauge is herein used to mean the same as workpiece strip thickness, and it is commonly also spelled gage by persons skilled in this art. At step **180** the percent deviation between the desired nominal gauge and the X-ray device measured actual gauge is now determined. At step **182** a limit check is made, and if it is too large a flag is set and an alarm message printed at step **184** and the program exits. If it is not too large, at step **186** a check is made to see if this is the first scan on the workpiece bar or strip; and if it is, a flag is set at step **188** and the program ends. If this is not the first scan on the bar, at step **190** a determination is made to see if this is the last head end scan on the bar. At step **192** the last head end scan flag is set. At step **194** the program goes through a predetermined adaptive routine, to be later described, and after that the program goes through a head end routine at step **196** to adjust the screw position setups of the respective roll stands for the next similar workpiece strip. At step **198** the actual head end gauge is determined. At step **200** a check is made to see if the operator has selected lock on gauge control operation, and if not at step **201** this gauge becomes nominal guage. At step **202** a check is made to see if the percent deviation is greater than some operator predetermined limit value, such as 10 percent. At step **204** a look-up table operation is provided in relation to operator provided values to reapply the desired or nominal strip gauge. At step **206** a new percent deviation is determined in relation to this new desired strip gauge.

At step **208** the last stand speed is determined, and a mass flow relationship including proportional integration of the established gauge error is the desired function to be performed here on a selected stand by stand basis, generally three such stands are selected by the operator. At step **210** the last stand is addressed, and now the correction of the selected stands occurs. At step **212** a check is made to see if the selected stand has calibrated screws, and at step **214** a check is made to see if the X-ray monitor operation has been selected by the operator for this stand. At step **216** the X-ray correction is determined for the selected stands, including the proportional integration function. This operation is continued for all selected stands. If the checks made at step **212** or **214** are failed, then the stand drive number is decremented at step **218** and a check is made at step **220** to see if this stand is number zero. At step **222** the correction is limited. At step **224** if the stand roll force gauge control system is turned off, then an X-ray correction is output for this stand at step **226**; this permits providing only the X-ray correction with the roll force system turned off for a given stand when desired by the operator. Step **228** is for incrementing the number of corrections. At step **230** a check is made to see if enough stands have been corrected. At step **232** a check is made to see if this stand under consideration is the first stand and at step **234** the last stand is addressed. At step **236** a determination is made of the required time delay to wait for the strip to pass from this stand to the next stand before the next correction is to be made in relation to the selected stands for the correction. This is a function of speed and distance involved.

In relation to the feed forward subroutine at step **64** of the AGC program flow chart shown in FIG. **6**C, in FIG. **8** there is shown a flow chart to illustrate the operation of this subroutine. At step **250**, if this is the last stand no gauge error correction can be fed forward in the direction of strip movement, so the subroutine ends. If this is the first sign of a skidmark at step **252**, a counter is set at step **254** and a flag is set at step **256**. The direction of the skidmark is determined at step **258**, for example, to see if a soft spot in the strip has occurred, and at step **260** the required transport time delay is calculated in relation to the strip speed through this stand. At step **262**, if this is not the first sign of a skidmark, the counter will be incremented each time the program runs. At step **264** the previous screw correction is made the new screw correction and the program then ends. At step **266** the transport time delay calculated at step **260** is saved, and at step **268** the stand that feeds forward is addressed.

In relation to the feedback subroutine at step **84** of the AGC program flow chart shown in FIG. **6**B, in FIG. **9** there is shown a flow chart to illustrate the operation of this subroutine. At step **270**, if this is the first stand no error correction can be fed back to an earlier stand so the program ends. At step **272** the preceding stand N-**1** is addressed, with the present stand being stand N. At step **274** the desired flags are picked up, and it is now desired to check why the feedback subroutine was entered. At step **276**, it is determined if the roll force load cell of the previous stand N-**1** was faulty, and if so at step **278** the desired feedback correction applied to stand N-**1** is calculated. If the roll force signal was provided at stand N-**1**, then at step **280** a check is made to see if the stand N-**1** screw positioning mechanism was properly calibrated and if so the feedback correction is calculated at step **278**. In general, the feedback subroutine can be entered if stand N went into screw position limits as well as if the load cell of stand N-**1** was faulty, and steps **276** and **280** are related to the happening of one of these events. At step **282**, the stand address indexing is set up, and the subroutine exits back to the AGC program shown in FIG, **6**C.

In relation to the adaptive routine at step **194** of the X-ray program flow chart shown in FIG. **7**A, in FIG. **10** there is shown a logic flow chart to illustrate the operation of this subroutine. An adaptive routine will be done to calculate the mean plasticity value and a standard deviation for each such plasticity value for this workpiece gauge class and for each roll stand. At step **300** there are determined the last stand speed and exit thickness; the exit thickness as measured by the X-ray device and the last stand speed are needed in order to establish the mass flow relationships. Digital speed measurement circuitry is used to determined each of the stand speeds. Now the mean plasticity value and the standard deviation for that value are calculated for each of the stands, starting with the address of the first stand at step **302**. Is this stand calibrated is checked at step **304**. If it is not, the adaptive program exits to the head end routine. Using mass flow at step **306** from the stand speed, the exit gauge is determined. If this stand is the first stand at step **308**, the program goes to step **309** because of inability to mass flow the first stand in relation to stand zero to determine the entry gauge and the program therefore cannot calculate plasticity value for the first stand. If it is not the first stand at step **308**, the program goes to step **310** to read the nominal width of the workpiece strip, so the width is read from operator input thumbwheels and a calculation is made of the plasticity constant PW at step **312**. The side-guard position could perhaps be fed back as an indication of workpiece width. A validity check is made at step **314** to make sure the calculated plasticity value for stand N is positive, which it should be and if it is not positive the program exits to the head end routine. A determination is made of the gauge class at step **316** for storage. At step **318** the mean plasticity or average plasticity value for this gauge class is determined, at step **320** the standard deviation is calculated and at step **322** it is stored away according to gauge class of workpiece product. At step **324** a determination is made to see if this is the last roll stand, and if it is not the program goes back to step **309** for processing each of the stands of the rolling mill. If this is the last stand at step **324**, the program exits to the head end routine.

In relation to the head end correction routine at step **196** of the X-ray program flow chart shown in FIG. **7**A, in FIG. **11** there is shown a logic flow chart to illustrate the operation of this subroutine.

The speed RPM_{LS} of the last stand is read at step **400**. The weighting factors are initialized at step **402** and set up to index through each of the stands, with the head end weighting factor being set equal to **1** and the other selected stand weighting factors being set respectively equal to **2** and **3** for the purpose of providing the desired three/thirds, two/thirds and one/third relationship for three selected roll stands, for example, going back from stand **6**, to stand **4** and then to stand **2**. At step **404** the stand number is decreased and at step **406** a determination is made to see if X-ray gauge deviation correction is selected to monitor the operation of this stand. If it is, at step **408** the desired correction is determined for this stand. If it is not, at step **410** the stand number is decreased and step **412** checks to see if this stand is equal to zero. This operation will give the desired three/thirds, two/thirds and one/third gauge deviation correction relationship for the respective selected stands. When the stand weighing factor WF equals zero, the program subroutine will exit or end. After the function of step **408**, the program goes to step **414** where the stand number is decreased, and then step **416** decreases the weighting factor and step **418** checks to see if the stand weighting factor is zero. If not, the program goes back to step **406**. At step **408** the correction for this stand is determined by the relationship:

$$\text{CORRECTION} = (FPM_{LS}/FPM_{TS})\ (\text{X-ray Gauge Deviation/weighting factor}) \quad (19)$$

where the weighting factor for the higherst stand number is one and for the lowest stand thenumber is three and the ratio of last stand speed is with this stand speed.

The monitor switch is provided for the operator to select the X-ray correction function or not.

Functionally, the main roll force AGC operates when the analog scan program initiates the roll force AGC program level each time a stand's roll force or an X-ray deviation is scanned at periodic intervals of every 2/10 second.

In order for AGC corrections to be made to a given stand, the following conditions must exist:

1. "AGC Master" must be selected as determined at step **10.**

2. "Roll Force" must be selected for the stand as determined at step **16.**

3. The stand must be in the automatic mode as determined at step **18.**

4. The stand's screws must be calibrated as determined at step **24.**

If any one of the four is not met, the AGC program exists without making a correction.

If a strip has just entered the stand as determined at step **26,** and this is the first scan check on the strip as determined at step **28,** "lock-on" or initial values for the screw position and roll force are established at step **30,** and values of mill spring constant and product plasticity are selected.

Each time a stand's roll force is scanned by the analog scan program, its new value is checked against the initial lock-on value and any deviation in roll force is directly related to an error in the stand's exit gauge at step **50** which is in turn directly related to a screw opening correction determined at step **52.** If the screw correction is within a preestablished deadband at step **54,** it is ignored at step **56.** Otherwise it is checked to determine if it is greater than an operator provided maximum limit at step **60.** If the screw correction does determine if it is greater than an operator provided maximum limit at step **60.** If the screw correction does exceed the limit, a correction is made not only to this stand but also the next stand. Correcting the next stand (N + 1) from this stand (N) data is called feed forward. If a large screw correction is required on stand N, the time required to move the screwdown mechanism to make the correction may be long enough to cause a section of the strip to pass through the stand uncorrected. To catch the uncorrected portion, a screw opening correction is made to the next stand (N + 1) in anticipation of the arrival of the section. This correction is made T seconds after the distrubance is detected in stand N, where T is slightly less than the transport time between stand N and (N + 1). Likewise T seconds after the disturbance disappears from stand N, the correction is removed from stand (N + 1). If the screw correction for the stand under consideration is within predetermined limits at step **60** no feed forward correction is made.

The new position of the screws is calculated at step **72.** Before a screw is corrected, its absolute position is checked at step **82** to see if it is presently at one of its minimum bound or maximum bound. If the screw is positioned to one of its limits, and the correction will cause it to exceed that limit, a feedback correction is determined at step **84** to the entry gauge of this stand (stand N).

The following conditions must be met before a feedback can be made from stand N:

1. Stand N is not stand **1** as determined at step **270.**

2. The load cell for stand (N−1) is not on or stand N is out of limits as determined at step **86** and at step **82.**

3. The load cell for stand N is on as determined at step **88.**

4. A feedback from stand N is not already in progress.

If all conditions are met, the feedback subroutine at step **84** and in accordance with the flowchart of FIG. **9** is entered.

The feedback routine makes three checks on stand **N-1**:

1. (N−1) is not 0 at step **270.**

2. The screw for stand (N−1) is not at the same limit as stand N at step **274,** i.e., if stand N is at its up limit, stand (N−1) is not at its up limit.

3. The screws for stand (N−1) are in calibration at step **280.**

If all three checks are true, a feedback correction to the exit gauge of stand (N−1) is made. A predetermined time delay is initiated so that no further feedback can be made to stand (N−1) until the present feedback correction reaches stand N. The time delay is equal to the transport time between stand (N−1) and stand N.

After all corrections have been made to a stand, the net direction of the movement of the screws is determined at steps **112** and **114** and a signal is sent to the looper stand speed controls at one of steps **116** and **118** indicating that direction. If the screws are moved down, the looper preceding the screws will tend to be moved up. If the screws are moved up the preceding looper tends to move down. Any looper movement causes corresponding speed correction to an adjacent stand to maintain constant looper height. Each time a screwdown is moved, a speed correction is sent in anticipation of the looper height change.

The function of the X-ray monitor program is to provide a reading, in absolute units of measure, of the finished product gauge. The roll force AGC system is based on changes in screw position (and therefore product gauge) rather than absolute position and for that reason, there may be a discrepancy between desired gauge and actual gauge. The X-ray provides a reference for this comparison.

The X-ray information is used in one of two ways. If the last stand roll force is inoperative or failed the calibration tests for other reasons, the last stand is positioned by the X-ray monitor. On the other hand, if the last stand is being positioned by roll force AGC, then the last three stands, whose screws are calibrated, are corrected to produce the desired gauge.

In addition, the X-ray monitor program at step **194** updates a table of average values of product plasticity, P and makes head end corrections at step **196.** The head end routine calculates an offset for this stand, based on the X-ray deviation, to add to the initial stand screw positions for the next similar strip which is to follow the strip being rolled. This procedure allows bad initial screw setups provided by the operator to be corrected in relation to subsequent strips which follow.

It is generally known and understood by persons skilled in this particular art of applying a computer control system that a combined hardware and software process control system comprises a special purpose extended control computer machine, and is provided when a general purpose computer is operated under the control of one or more software instruction programs. Such a process control system can be built if desired using hardware or wired logic programming in relation to the functional steps set forth in the flow charts, in view of the recognized general equivalence of a software programming embodiment and a hardware programming embodiment and a hardware programming embodiment of substantially the same control system. However, when an involved industrial application such as here described becomes somewhat complex, the economics tend to favor the software approach due to the greater expense and lack of flexibility when hardware logic circuits, such as well known NOR logic circuits, are wired together to provide the desired circuit arrangement built up of such logic circuits to perform the sequential program steps set forth in the illustrated flow charts.

DESCRIPTION OF THE PREFERRED EMBODIMENT

When the tail end of a strip drops out of a stand, the AGC program operation must prepare the stand for the next strip by resetting its screws. If the next strip is to be the same gauge as the previous strip, and if during the rolling of the previous strip the initial screw set-up resulted in an immediate X-ray gauge deviation, that error should be taken into consideration when setting up the screws for the next strip. This is accomplished by calculating a correction for each of selected roll stands which is added to the screw position reference for the next strip's initial screw set-up. The first X-ray guage reading on a strip is ignored since it may have been taken on the initial head end portion of the strip which is usually distorted. When the X-ray scans a new strip for the second time, the head end corrections are calculated and stored for the next strip. The X-ray corrections are based on the gauge deviation reading from the X-ray device, in most applications and no correction is applied to the last stand. Only stands whose X-ray monitors are selected are corrected, with a predetermined limit such as three stands being selected.

The function of the head end routine is to enable the computer system to aid the operator in the initial set up of each roll stand in the rolling mill. The AGC programmed computer system is operative such that the operator dials in the desired screwdown position reference for each stand by means of a thumbwheel, and the computer system sets the screw openings of the respective roll stands to those position references. Then a workpiece is rolled and the head end of that workpiece will end up being at whatever gauge corresponds to those reference screw positions. One problem is that the operator does not consistently get those reference screw positions correct on the first try, and each roll stand commonly ends up rolling a workpiece gauge that is excessively heavy or excessively thin, so the operator provided set ups need to be changed. Under the prior art gauge control system operation the operator would eyeball the desired change for each stand by himself, but those changes in and by steps of successive approximations the operator would arrive at a set of positions for the respective screws for that particular product for that day that would result in reasonably good delivery gauge from the rolling mill at the front end of the subsequent bar.

In accordance with the present invention, the AGC programmed computer system still cannot do much about the front end of the first strip or bar, since it does not have enough learned information at this time, bu the AGC computer system can replace the operator function in the successive approximations for obtaining better and more correct gauge in the head end portion of the subsequent similar bars.

When the head end of the first workpiece strip has passed through all of the roll stands and enters the X-ray gauge positioned after the last roll stand, a delay for a short predetermined time period is provided and then the head end thickness deviation is measured at the X-ray. This deviation is used as an indication of how satisfactory the initial operator provided set ups were. Then a gauge deviation correction is calculated in relation to the initial operator provided set ups, and this gauge deviation correction will equal the head end gauge deviation at the X-ray gauge times the mass flow relationship with the stand to be corrected, times a dissipative constant. The determined gauge deviation correction is then applied to the stand screws and the screw position for the next strip will equal the screw position for the previous strip plus or minus this determined correction, depending upon the gauge deviation being negative or positive in relation to the desired target gauge. The full determined correction would be applied to the selected stand having the highest stand number, while the screws of the selected stand having the middle stand number would receive a fractional correction such as two/thirds of the full correction, and the screws of the selected stand having the lowest stand number would receive a fractional correction such as one/third of the full correction. If desired, more than three stands can be corrected, such as five stands of correction being provided in this manner instead of three.

This AGC program can be operative with a smaller digital computer gauge control system having no process model equations to determine the initially provided respective stand screw settings or stand screwdown schedules, so the operator can be using his own skill and knowledge to set the initial screw setting for each stand and then the here disclosed control system becomes operative to quickly correct these initial manual stand screw position set ups.

The here described head end correction routine uses a mass flow relationship to determine corrections applied to the operator provided screwdown set ups, and is operative with the smaller computer and provides a head end correction for only selected roll stands based upon the measured X-ray deviation for the head end portion of the workpiece. This X-ray gauge deviation is determined by the X-ray device positioned after the last stand, and is equal to the difference between the operator desired target gauge delivered by the last stand and the measured actual guage delivered by the last stand. An average X-ray measured gauge deviation is assumed to apply for the whole strip, and it is being used in relation to the whole of the next similar work strip.

A digital speed measurement for each stand is provided, and the head end correction operation uses that digital speed measurement for each selected stand to calculate the mass flow relationship delivery gauge error for stand N to correct the screwdown set up for stand N for the next similar workstrip. The latter set up lock on screwdown setting values are for selected stands for the rolling of the next similar workstrip in relation to the gauge error measured from the last stand,

and this gauge error is distributed among selected previous roll stands. The lock on X-ray measured gauge deviation is measured and applied back by mass flow relationships to correct the head end rolling of the next workstrip. The measured gauge error is ratio applied back to the selected roll stands by mass flow and weighting factors. The lock on screw setting for next workstrip is determined by the operator and then corrected by the here described gauge error corrections. This X-ray gauge deviation feedback correction is applied every 2/10 second for the entire length of the workstrip and provides a screw position correction in addition to the operator selected screw position.

GENERAL DESCRIPTION OF INSTRUCTION PROGRAM LISTING

In the Appendix there is included an instruction program listing that has been prepared to control the roll force automatic gauge control operation of a tandem rolling mill in accordance with the here disclosed control system and method. The instruction program listing is written in the machine language of the PRODAC P2000 digital computer system, which is sold by Westinghouse Electric Corporation for real time process control computer applications. Many of these digital computer systems have already been supplied to customers, including customer instruction books and descriptive documentation to explain to persons skilled in this art the operation of the hardware logic and the executive software of this digital computer system. This instruction program listing is included to provide an illustration of one suitable embodiment of the present control system and method that has actually been prepared. This instruction program listing at the present time is a more or less development program and has not been extensively debugged through the course of practical operation for the real time automatic gauge control of a tandem rolling mill. It is well known by persons skilled in this art that most real time process control application programs contain some bugs or minor errors, and it is within the skill of such persons and takes varying periods of actual operation time to identify and correct the more critical of these bugs.

A person skilled in the art of writing computer instruction program listings, particularly for an invention such as the present roll force automatic gauge control system and method for a tandem rolling mill must generally go through the following determinative steps:

Step One — Study the workpiece rolling mill and its operation to be controlled, and then establish the desired control system and method concepts.

Step Two — Develop an understanding of the control system logic analysis, regarding both hardware and software.

Step Three — Prepare the system flowcharts and/or the more detailed programmer's flowcharts.

Step Four — Prepare the actual computer instruction program listings from the programmer's flowcharts. This instruction program listing included in the Appendix was prepared in relation to the programmer's flowcharts shown in FIGS. 6 and 11.

```
AGC DATA FILE
                      BIN
                      ABS
                      TTL     'AGC DATA FILE'

          *                                   FILES ARE EITHER X'CO' OR X'60'
          *                                   IN LENGTH

          *                                   REVISED  3/31/71

          *    THE FOLLOWING IS A COMPLETE LISTING OF THE AGC DATA
          *      FILE ENTRIES;

1000        FILE      ORG     X'1000'
1000        FLSIZE    ORG     $               NUMBER OF WORDS IN THIS DATA FILE
1001        FWPFLS    ORG     $+1             REL.ADDR.OF FWD.PROFILES B/A
1002        RVPFLS    ORG     $+1             REL.ADDR.OF REV. PROFILES B/A
1003        FXDCON    ORG     $+1             REL.ADDR. OF FIXED POINT CONST'S
1004        REVCNT    ORG     $+1             ENCODER REVOLUTION COUNT
1005        REFENC    ORG     $+1             REF. IN ENCODER UNITS
1006        FBENC     ORG     $+1             CURRENT ENCODER READING IN GRAY
1007        OFFSET    ORG     $+1             CALIBRATION OFFSET
1008        CALPNT    ORG     $+1             ENCODER CALIBRATION POINT(2 WDS)
1009                  ORG     $+1
100A        ENCNO     ORG     $+1             IOA INSTR.TO INPUT ENC.READING
100B        WKDATA    ORG     $+1             SPEED PATTERN INFO
100C        CLREG     ORG     $+1             CLOSED LOOP REGISTER NUMBER
100D        ZEROCO    ORG     $+1             ZERO ERROR CO IF INCLUDED
100E        ENGREF    ORG     $+1             REF.IN ENGINEERING UNITS (2 WDS)
100F                  ORG     $+1
1010        BINPT     ORG     $+1             LOC.OF BINARY PT IN FIXED PT.WDS.
1011        CALFLAG   ORG     $+1             DRIVE IN CALIBRATION FLAG
1012        PFLCAL    ORG     $+1             S.D.PROFILE CALIB'TN FLAG
1013        PROFIL    ORG     $+1             AUXILIARY S.D. PROFILE INDIC'TR
1014        PROLOC    ORG     $+1             PRESENT ACTION PT. OF S.D.PROFILE
1015        SPDPAT    ORG     $+1             SPEED PATTERN MASK
1016        INTDLY    ORG     $+1             TIME DELAY FOR INT.STOP DELAY
1017        INTCNT    ORG     $+1             INT.STOP COUNT-DOWN WORD
1018        TIMMAX    ORG     $+1             MAX. ERROR TO C.D. TIME
1019        ERRTIM    ORG     $+1             COUNT-DOWN WORD FOR ERROR TO
101A        ZEFLAG    ORG     $+1             ZERO ERROR FLAG
101B        TOFLAG    ORG     $+1             TIME OUT FLAG
101C        CONFAC    ORG     $+1             CONVERSION FACTOR F.P. MODE (2 WDS)
101D                  ORG     $+1
101E        ZEROFF    ORG     $+1             MECH. OFFSET F.P. MODE (2 WDS)
101F                  ORG     $+1
1020        TOLENC    ORG     $+1             TOLERANCE IN ENCODER UNITS
1021        ANTPAT    ORG     $+1             NUMBER OF ANTICAIPATE PTS IN PROFS.
                      EJE
          *                                   THIS SECTION IS ALWAYS REQUIRED
          *                                   FOR ALL DRIVES IN AN AGC SYSTEM

1022        BCDDIG    ORG     $+1             NUMBER OF BCD DIGITS IN TW REF
          *                                   ADDRESS OF FIRST WORD FOR STAND
          *                                   IN MCI TABLE
1023        MCI       ORG     $+1
```

AGC DATA FILE

```
1024   PRSET      ØRG    $+1    FLAG INDICATING PRESET WAS JUST DØNE
       *                        REQUEST FØR BID TØ PRESET PRØGRAM
       *                        IF FLAG IS -1
1025   REBID8     ØRG    $+1
       *                        PØSITIØN REFERNCE FØR MØVING SCREWS
       *                        ØN STRIP BIT ØF STAND
1026   RESET      ØRG    $+1
       *                        STRIP IN STAND FLAG
1027   SIS        ØRG    $+1
1028   FB3        ØRG    $+1    F.B. FRØM PREVIØUS 0.3 SECØNDS
1029   FEEDBK     ØRG    $+1    CURRENT F.B. IN ENCØDER UNITS
       *                        CALIBRATIØN REJECTIØN FLAG
102A   NØTCALIB   ØRG    $+1
       *                        MAXIMUM SLSYN SPEED IN RPM
102B   MAXSPD     ØRG    $+1
102C   SELPWR     ØRG    $+1    SELSYN PØWER CØ LØCATIØN
       *                        ADDRESS ØF THUMBWHEEL REFERENCE
102D   TWMCI      ØRG    $+1
       *                        SPEED IN MPM
102E   SPEEDM     ØRG    $+1
       *                        CALIBRATIØN SPEED
102F   CØRSPEED   ØRG    $+1
       *                        CALIBRATIØN FØRCE
1030   CØRFØRCE   ØRG    $+1
1031              ØRG    $+1    SPARE
1032              ØRG    $+1    SPARE
1033              ØRG    $+1    SPARE
1034              ØRG    $+1    SPARE
1035              ØRG    $+1    SPARE
1036              ØRG    $+1    SPARE
1037              ØRG    $+1    SPARE
1038              ØRG    $+1    SPARE
1039              ØRG    $+1    SPARE
103A              ØRG    $+1    SPARE
103B              ØRG    $+1    SPARE
                  EJE
       *                        THIS SECTIØN IS ØNLY REQUIRED
       *                        FØR DRIVES UNDER AGC CØNTRØL
       *                        I.E. SCREWS.


       *                        NEG. LIMIT FØR XRAY SCREW CHANGE
103C   NEGLIMT    ØRG    $+1
       *                        PØS. LIMIT FØR XRAY SCREW CHANGE
103D   PØSLIM     ØRG    $+1
       *                        MAX SCREW CHANGE FØR AGC
103E   MAXDELTA   ØRG    $+1
       *                        REAL SCREWDØWN LØCK-ØN
103F   REALSDLØ   ØRG    $+1
       *                        SPEED LØCK-ØN
1040   SPEEDLØ    ØRG    $+1
       *                        PULSES PER REVØLUTIØN
1041   PPERREV    ØRG    $+1
       *                        CLASS TABLE PØINTER
1042   CLASS1     ØRG    $+1
       *                        CARD/PT FØR THIS LØØPER
1043   CARDPT     ØRG    $+1
       *                        CHANNEL NØ. FØR THIS LØØPER
1044   LØØPCHNØ   ØRG    $+1
       *                        GAIN FØR THIS LØØPER
1045   LØØPGAIN   ØRG    $+1


       *                        THESE SLØTS ARE UNIQUE TØ USINØR

       *                        THIS IS RØLL SPEED REFERENCE IN
       *                        METERS/MIN
1046   SPDREF     ØRG    $+1
       *                        NØ ØF BCD DIGITS IN SPEED THUMBWHEEL
1047   SPDDIG     ØRG    $+1
       *                        MCI WØRD FØR SPEED
1048   MCISPD     ØRG    $+1
       *                        'REBID8' FLAG FØR SPEED PRESET
1049   RBDSPD     ØRG    $+1


       *                        AV. GAUGE ERRØR WEIGHT FACTØR
104A   AGCWF      ØRG    $+1
       *                        ANALØG SCAN FØRCE
104B   ANFØRCE    ØRG    $+1
       *                        AVERAGE GAUGE ERRØR USED BY FEEDBACK
104C   AVERR      ØRG    $+1
       *                        TRANSPØRT TIME DELAY FØR FEEDBACK
104D   BACKTIME   ØRG    $+1
       *                        RØLL CIRCUMFRANCE IN MILLIMETERS
104E   CIRCUM     ØRG    $+1
       *                        TAILEND CØMPENSATIØN VALUE
104F   CØMPEN     ØRG    $+1
       *                        DEADBAND CALCULATED BY CALIB. PRØGRA
       *                        IN ENCØDER UNITS
1050   DEADBAND   ØRG    $+1
1051   DELTAS     ØRG    $+1    CHANGE IN S.D. FØR THIS STAND
       *                        STAND TØ RECEIVE FEEDBACK
1052   FDBK       ØRG    $+1
       *                        FEEDBACK CØRRECTIØN TØ PØSITIØNING
1053   FEEDØUT    ØRG    $+1
       *                        SKID TRANSPØRT TIME
1054   FEEDTIME   ØRG    $+1
       *                        FEEDBACK IN PRØGRESS FLAG
1055   FIP        ØRG    $+1
       *                        FØRCE LØCK ØN
1056   FØRCELØ    ØRG    $+1
```

AGC DATA FILE

```
          *                                FIRST SCAN ON STRIP FLAG
1057      FRSTSCAN ORG      $+1
          *                                FLAG FOR FIRST SCAN ON SKID
1058      FRSTSKID ORG      $+1
          *                                FLAG FOR FIRST SCAN ON TAIL
1059      FRSTTAIL ORG      $+1
          *                                GAUGE ERROR
105A      GE       ORG      $+1
          *                                FLAG FOR HEAD END OF STRIP
105B      HEADEND  ORG      $+1
          *                                GAIN ON PROPORTIONAL INTEGRATOR
105C      J1       ORG      $+1
          *                                MILL MODULUS FOR STAND
105D      K        ORG      $+1
          *                                STAND LIMIT FLAG
          *                                +1 WHEN IN UP LIMIT
          *                                0 WHEN NOT IN LIMIT
          *                                -1 WHEN IN DOWN LIMIT
105E      LIMFLAG  ORG      $+1
          *                                FLAG NOT TO SAVE HEAD END
105F      MANCOMP  ORG      $+1
          *                                MAXIMUM ALLOWABLE % DEVIATION OF K
1060      MAXK     ORG      $+1
          *                                MAXIMUM ROLL SPEED IN RPM
1061      MAXRPM   ORG      $+1
          *                                SKID DIRECTION FLAG
1062      MOVEUP   ORG      $+1
          *                                STRIP VELOCITY IN METERS PER MINUTE
1063      MPM      ORG      $+1
          *                                OLD POSITION REFERENCE
1064      OLDREF   ORG      $+1
          *                                ADDITIONAL SCREW POSITION CHANGES
1065      OTHER    ORG      $+1
          *                                PLASTICITY
1066      PLAST    ORG      $+1
1067      PLSCHL   ORG      $+1            INPUT CHANNEL FOR PULSE TACH
          *                                REFERENCE FOR POSITION PROGRAM
1068      POSITION ORG      $+1
          *                                TABLE OF PW VALUES
          *                                IN UNITS OF ENCODER UNITS*DECIMETERS
          *                                PER KILOTON
1069      PTABLE   ORG      $+1
1071               ORG      $+8
1072      PULSE    ORG      $+1            CURRENT PULSE READING
          *                                TABLE OF PW MEAN VALUES
1073      PWTABLE  ORG      $+1
107B               ORG      $+8
          *                                ROLL DIAMETER REGISTER
107C      RDIAMREG ORG      $+1
          *                                ROLL DIAMETER READ BY THIS PROGRAM
107D      ROLLDIAM ORG      $+1
          *                                NUMBER OF SAMPLES OF EACH PW
107E      SAMPLSIZ ORG      $+1
1086               ORG      $+8
          *                                SCREW DOWN LOCK ON
1087      SDLO     ORG      $+1
          *                                SECOND SCAN ON STRIP FLAG
1088      SCNDSCAN ORG      $+1
          *                                SCREW FEEDBACK
1089      SCREW    ORG      $+1
          *                                DISTANCE TO NEXT STAND
          *                                IN MILLIMETERS
108A      SEPARATE ORG      $+1
          *                                DELTA S OF PREVIOUS SCAN
108B      SKIDS    ORG      $+1
          *                                LENGTH OF SKID MARK
108C      SKIDSIZE ORG      $+1
          *                                MILL REVOLUTIONS PER MINUTE
108D      SPEED    ORG      $+1
          *                                SQUARED STANDARD DEVIATION OF PW
108E      STANDEV  ORG      $+1
1096               ORG      $+8
          *                                TAIL END COMPENSATION FLAG
1097      TAILCOMP ORG      $+1
          *                                TAIL END COMPENSATION TRANSPORT TIME
1098      TAILTIME ORG      $+1
          *                                POSITIONING REFERENCE FOR TEMP
          *                                COMPENSATION
1099      TCOMPVAL ORG      $+1
          *                                TEMP COMPENSATION ON STRIP OUT OF ST
109A      TCOMSOS  ORG      $+1
          *                                CALCULATED OUTPUT GAUGE
109B      THICK    ORG      $+1
                   EJE
          *                                THIS SECTION IS REQUIRED FOR ALL
          *                                 DRIVES IN THE SYSTEM.

109C      L1       ORG      $+1            FEEDBACK PROPORT. INT. CONSTANT
109D      L2       ORG      $+1            FEEDBACK PROPORT. INT. CONSTANT
109E      L3       ORG      $+1            FEEDBACK PROPORT. INT. CONSTANT
109F      L4       ORG      $+1            FEEDBACK PROPORT. INT. CONSTANT
10A0      FXDOFF   ORG      $+1            FIXED PT. OFFSET
10A1      FXDMUL   ORG      $+1            FIXED PT. MULT. FACTOR
10A2      FXDSHF   ORG      $+1            'ORA' +X CODE
10A3      PROFWA   ORG      $+1            FUWARD FROFILE A
10A4      PRORVA   ORG      $+1            REVERSE PROFILE A
10A5      OPTFLGS  ORG      $+1            SPEED LIMIT OPTION FLAGS
10A6      REVLIM   ORG      $+1            REVERSE POSITION LIMIT
10A7      FWDLIM   ORG      $+1            FORWARD POSITION LIMIT
10A8      SPEEDS   ORG      $+1            FORWARD/REVERSE SPEED LIMITS
```

AGC TABLES

```
                               0258          TTL      'AGC TABLES'
 1CC0                          0259          ORG      X'1CC0'
                               0260   *                            GAUGE CLASSIFICATION TABLE FOR
                               0261   *                            EXIT GAUGES.  VALUE IS IN ENCODER
                               0262   *                            UNITS + 600 (THE MECH. OFFSET OF
                               0263   *                            -1000)
                               0264   *
                               0265   *                            DRIVE 1 DATA
 1CC0  098A   08 1 BA A        0266          DAT      2490
 1CC1  0A28   08 2 28 A        0267          DAT      2600
 1CC2  0A96   08 2 96 A        0268          DAT      2710
 1CC3  0B04   08 3 04 A        0269          DAT      2820
 1CC4  0B72   08 3 72 A        0270          DAT      2930
 1CC5  0BEA   08 3 EA A        0271          DAT      3050
 1CC6  0C62   08 4 62 A        0272          DAT      3170
 1CC7  0D48   08 5 48 A        0273          DAT      3400
                               0274   *                            DRIVE 2 DATA
 1CC8  0744   00 7 44 A        0275          DAT      1860
 1CC9  07AD   00 7 AD A        0276          DAT      1965
 1CCA  0816   08 0 16 A        0277          DAT      2070
 1CCB  087F   08 0 7F A        0278          DAT      2175
 1CCC  08E8   08 0 E8 A        0279          DAT      2280
 1CCD  0951   08 1 51 A        0280          DAT      2385
 1CCE  09BA   08 1 BA A        0281          DAT      2490
 1CCF  0A8C   08 2 8C A        0282          DAT      2700
                               0283   *                            DRIVE 3 DATA
 1CD0  0596   00 5 96 A        0284          DAT      1430
 1CD1  0604   00 6 04 A        0285          DAT      1540
 1CD2  0672   00 6 72 A        0286          DAT      1650
 1CD3  06E0   00 6 E0 A        0287          DAT      1760
 1CD4  074E   00 7 4E A        0288          DAT      1870
 1CD5  07BC   00 7 BC A        0289          DAT      1980
 1CD6  07D0   00 7 D0 A        0290          DAT      2000
 1CD7  088E   08 0 8E A        0291          DAT      2190
                               0292   *                            DRIVE 4 DATA
 1CD8  04CE   00 4 CE A        0293          DAT      1230
 1CD9  0528   00 5 28 A        0294          DAT      1320
 1CDA  0582   00 5 82 A        0295          DAT      1410
 1CDB  05DC   00 5 DC A        0296          DAT      1500
 1CDC  0636   00 6 36 A        0297          DAT      1590
 1CDD  0690   00 6 90 A        0298          DAT      1680
 1CDE  06EA   00 6 EA A        0299          DAT      1770
 1CDF  078A   00 7 8A A        0300          DAT      1930
                               0301   *                            DRIVE 5 DATA
 1CE0  042E   00 4 2E A        0302          DAT      1070
 1CE1  047A   00 4 7A A        0303          DAT      1146
 1CE2  04C6   00 4 C6 A        0304          DAT      1222
 1CE3  0512   00 5 12 A        0305          DAT      1298
 1CE4  055E   00 5 5E A        0306          DAT      1374
 1CE5  05AA   00 5 AA A        0307          DAT      1450
 1CE6  05FA   00 5 FA A        0308          DAT      1530
 1CE7  0690   00 6 90 A        0309          DAT      1680
                               0310   *                            DRIVE 6 DATA
 1CE8  03DE   00 3 DE A        0311          DAT      990
 1CE9  0420   00 4 20 A        0312          DAT      1056
 1CEA  0462   00 4 62 A        0313          DAT      1122
 1CEB  04A4   00 4 A4 A        0314          DAT      1188
 1CEC  04E6   00 4 E6 A        0315          DAT      1254
 1CED  0528   00 5 28 A        0316          DAT      1320
 1CEE  056E   00 5 6E A        0317          DAT      1390
 1CEF  05F0   00 5 F0 A        0318          DAT      1520
                               0319   *                            DRIVE 7 DATA
 1CF0  03C0   00 3 C0 A        0320          DAT      960
 1CF1  03EE   00 3 EE A        0321          DAT      1006
 1CF2  041C   00 4 1C A        0322          DAT      1052
 1CF3  044A   00 4 4A A        0323          DAT      1098
 1CF4  0478   00 4 78 A        0324          DAT      1144
 1CF5  04A6   00 4 A6 A        0325          DAT      1190
 1CF6  04D8   00 4 D8 A        0326          DAT      1240
 1CF7  053C   00 5 3C A        0327          DAT      1340
                               0328
                               0329
 1D00                          0330          ORG      X'1D00'
                               0331   *                            TABLE OF FORCES FOR SELECTING K'S
                               0332   *                            IN UNITS OF METRIC TONS
                               0333   *                            FIRST ENTRY IS SMALLEST
                               0334   *                            ADJUST IN FIELD
       1D00   18 5 00 A        0335   FORCE1 EQU      *
                               0336   *                            DRIVE 1 DATA
 1D00  0000   00 0 00 A        0337          DAT      0
 1D01  0258   00 2 58 A        0338          DAT      600
 1D02  04B0   00 4 B0 A        0339          DAT      1200
 1D03  0708   00 7 08 A        0340          DAT      1800
 1D04  0960   08 1 60 A        0341          DAT      2400
 1D05  0BB8   08 3 B8 A        0342          DAT      3000
                               0343   *                            DRIVE 2 DATA
 1D06  0000   00 0 00 A        0344          DAT      0
 1D07  0258   00 2 58 A        0345          DAT      600
 1D08  04B0   00 4 B0 A        0346          DAT      1200
 1D09  0708   00 7 08 A        0347          DAT      1800
 1D0A  0960   08 1 60 A        0348          DAT      2400
 1D0B  0BB8   08 3 B8 A        0349          DAT      3000
                               0350   *                            DRIVE 3 DATA
 1D0C  0000   00 0 00 A        0351          DAT      0
 1D0D  0258   00 2 58 A        0352          DAT      600
 1D0E  04B0   00 4 B0 A        0353          DAT      1200
 1D0F  0708   00 7 08 A        0354          DAT      1800
 1D10  0960   08 1 60 A        0355          DAT      2400
 1D11  0BB8   08 3 B8 A        0356          DAT      3000
                               0357   *                            DRIVE 4 DATA
 1D12  0000   00 0 00 A        0358          DAT      0
 1D13  0258   00 2 58 A        0359          DAT      600
```

AGC TABLES

```
1D14  04B0   00 4 B0 A                  DAT    1200
1D15  0708   00 7 08 A                  DAT    1800
1D16  0960   08 1 60 A                  DAT    2400
1D17  0BB8   08 3 B8 A                  DAT    3000
                              *                              DRIVE 5 DATA
1D18  0000   00 0 00 A                  DAT    0
1D19  0258   00 2 58 A                  DAT    600
1D1A  04B0   00 4 B0 A                  DAT    1200
1D1B  0708   00 7 08 A                  DAT    1800
1D1C  0960   08 1 60 A                  DAT    2400
1D1D  0BB8   08 3 B8 A                  DAT    3000
                              *                              DRIVE 6 DATA
1D1E  0000   00 0 00 A                  DAT    0
1D1F  0258   00 2 58 A                  DAT    600
1D20  04B0   00 4 B0 A                  DAT    1200
1D21  0708   00 7 08 A                  DAT    1800
1D22  0960   08 1 60 A                  DAT    2400
1D23  0BB8   08 3 B8 A                  DAT    3000
                              *                              DRIVE 7 DATA
1D24  0000   00 0 00 A                  DAT    0
1D25  0258   00 2 58 A                  DAT    600
1D26  04B0   00 4 B0 A                  DAT    1200
1D27  0708   00 7 08 A                  DAT    1800
1D28  0960   08 1 60 A                  DAT    2400
1D29  0BB8   08 3 B8 A                  DAT    3000


1D40                                    ØRG    X'1D40'
                              *                              TABLE ØF K'S FØR FØRCES
                              *                              IN ENCØDER UNITS PER KILØTIN
                              *                              ADJUST IN FIELD
      1D40   18 5 40 A        KTABLE    EQU    $
                              *                              DRIVE 1 DATA
1D40  0050   00 0 50 A                  DAT    80
1D41  00A0   00 0 A0 A                  DAT    160
1D42  00A0   00 0 A0 A                  DAT    160
1D43  00A0   00 0 A0 A                  DAT    160
1D44  00A0   00 0 A0 A                  DAT    160
1D45  00A0   00 0 A0 A                  DAT    160
                              *                              DRIVE 2 DATA
1D46  0050   00 0 50 A                  DAT    80
1D47  00A0   00 0 A0 A                  DAT    160
1D48  00A0   00 0 A0 A                  DAT    160
1D49  00A0   00 0 A0 A                  DAT    160
1D4A  00A0   00 0 A0 A                  DAT    160
1D4B  00A0   00 0 A0 A                  DAT    160
                              *                              DRIVE 3 DATA
1D4C  0050   00 0 50 A                  DAT    80
1D4D  00A0   00 0 A0 A                  DAT    160
1D4E  00A0   00 0 A0 A                  DAT    160
1D4F  00A0   00 0 A0 A                  DAT    160
1D50  00A0   00 0 A0 A                  DAT    160
1D51  00A0   00 0 A0 A                  DAT    160
                              *                              DRIVE 4 DATA
1D52  0050   00 0 50 A                  DAT    80
1D53  00A0   00 0 A0 A                  DAT    160
1D54  00A0   00 0 A0 A                  DAT    160
1D55  00A0   00 0 A0 A                  DAT    160
1D56  00A0   00 0 A0 A                  DAT    160
1D57  00A0   00 0 A0 A                  DAT    160
                              *                              DRIVE 5 DATA
1D58  0050   00 0 50 A                  DAT    80
1D59  00A0   00 0 A0 A                  DAT    160
1D5A  00A0   00 0 A0 A                  DAT    160
1D5B  00A0   00 0 A0 A                  DAT    160
1D5C  00A0   00 0 A0 A                  DAT    160
1D5D  00A0   00 0 A0 A                  DAT    160
                              *                              DRIVE 6 DATA
1D5E  0050   00 0 50 A                  DAT    80
1D5F  00A0   00 0 A0 A                  DAT    160
1D60  00A0   00 0 A0 A                  DAT    160
1D61  00A0   00 0 A0 A                  DAT    160
1D62  00A0   00 0 A0 A                  DAT    160
1D63  00A0   00 0 A0 A                  DAT    160
                              *                              DRIVE 7 DATA
1D64  0050   00 0 50 A                  DAT    80
1D65  00A0   00 0 A0 A                  DAT    160
1D66  00A0   00 0 A0 A                  DAT    160
1D67  00A0   00 0 A0 A                  DAT    160
1D68  00A0   00 0 A0 A                  DAT    160
1D69  00A0   00 0 A0 A                  DAT    160
```

AUTØMATIC GAUGE CØNTRØL

```
                                        TTL    'AUTØMATIC GAUGE CØNTRØL'
                              *
                              *                              THIS PRØGRAM MØDIFIED 3/15/71
                              *
                              *                              THIS PRØGRAM CØNTRØLS THE GAUGE ØF
                              *                              THE MILL BY THREE PRØCESSES:
                              *                              DIRECT ACTIØN BASED ØN RØLL FØRCE
                              *                              CALCULATIØNS ØF THE GAUGE ERRØR,
                              *                              FEED FØRWARD TØ HANDLE SKID MARKS,
                              *                              AND FEED BACK TØ HANDLE STANDS WHICH
                              *                              GØ ØUT ØF LIMITS. THE PRØGRAM ALSØ
                              *                              ØUTPUTS A CØRRECTIØN TØ THE LØØPERS.
                              *
4100                                    ØRG    X'4100'
4100  41A8   40 1 A8 A                  DAT    BEGIN-1
4101  0000   00 0 00 A                  DAT    0
4102  0000   00 0 00 A                  DAT    0
```

AUTOMATIC GAUGE CONTROL

```
4103  0000  00 0 00 A                    DAT    0
4104  0000  00 0 00 A                    DAT    0
4105  0000  00 0 00 A                    DAT    0
4106  0000  00 0 00 A                    DAT    0
4107  0000  00 0 00 A                    DAT    0
4108  0000  00 0 00 A                    DAT    0
4109  0000  00 0 00 A                    DAT    0
410A  0000  00 0 00 A                    DAT    0
410B  0000  00 0 00 A                    DAT    0
410C  0000  00 0 00 A                    DAT    0
410D  0000  00 0 00 A                    DAT    0
410E  0000  00 0 00 A                    DAT    0
410F  0000  00 0 00 A         D          DAT    0
                                         EJE
                              *
                              *                     THIS DATA MUST BE DEFINED BY PROGRAMMER
                              *
                              *
                              *                                          OUTPUT SYSTEM FOR LOOPERS
                              *                                          0 FOR DIGITAL SYSTEMS
                              *                                          1 FOR ANALOG SYSTEMS
      0001  00 0 01 A         DIGLOOP    EQU    1


4110  4001  40 0 01 A         AGCNUM     DAT    X'4001'
                              *
4111  007F  00 0 7F A         AGCPAT     DAT    X'7F'                    AGC LIGHTS CCO BIT PATTERN
                              *
4112  0004  00 0 04 A         AGCREG     DAT    4                        AGC LIGHT CCO REGISTER
                              *
4113  18F3  18 0 F3 A         AGCMREG    DAT    X'18F3'                  MASTER AGC REGISTER ADDRESS
                              *
4114  0000  00 0 00 A         AGCPAT1    DAT    0                        AGC LIGHT OFF CCO PATTERN
                              *
4115  0020  00 0 20 A         BITPAT1    DAT    X'20'                    AGC MASTER CCI BIT PATTERN
                              *
                              *                                          ROLL FORCE CCI BIT PATTERN
4116  0800  08 0 00 A         BITPAT2    DAT    X'800'                   (PER STAND BASIS)
                              *
                              *                                          AUTO STATUS CCI BIT PATTERN
4117  0100  00 1 00 A         BITPAT3    DAT    X'100'                   (PER STAND BASIS)
                              *
4118  0100  00 1 00 A         BITPAT4    DAT    X'100'                   TAIL END COMP. CCI BIT PATTERN
                              *
                              *                                          FEEDFORWARD TIME TO ADVANCE MOVING S
4119  0002  00 0 02 A         DELAY      DAT    2                        SCREWS IN TENTHS OF SECONDS

411A  1000  18 5 00 A         FORCEP     DAT    FORCE1                   POINTER TO FORCE TABLE

                              *                                          TABLE OF ACCEPTABLE LOCK ON GAUGES
                              *                                          IN E.U.
                              *                                          ADJUST IN FIELD
      411B  40 1 1B A         GAGETBLE   EQU    *
411B  0078  00 0 78 A                    DAT    120
411C  008C  00 0 8C A                    DAT    140
411D  00A0  00 0 A0 A                    DAT    160
411E  00B4  00 0 B4 A                    DAT    180
411F  00C8  00 0 C8 A                    DAT    200
4120  00DC  00 0 DC A                    DAT    220
4121  00F0  00 0 F0 A                    DAT    240
4122  0104  00 1 04 A                    DAT    260
4123  0118  00 1 18 A                    DAT    280
4124  012C  00 1 2C A                    DAT    300
4125  0140  00 1 40 A                    DAT    320
4126  0154  00 1 54 A                    DAT    340
4127  0168  00 1 68 A                    DAT    360
4128  017C  00 1 7C A                    DAT    380
4129  0190  00 1 90 A                    DAT    400
                              *
412A  0800  08 0 00 A         GAGEBIT1   DAT    X'800'                   XRAY 1 MEAS CCI BIT PATTERN
                              *
412B  2000  20 0 00 A         GAGEBIT2   DAT    X'2000'                  XRAY 2 MEAS CCI BIT PATTERN
                              *
412C  00F0  00 0 F0 A         HARDBITS   DAT    X'F0'                    HARDNESS CCI BIT PATTERN
                              *
412D  18F1  18 0 F1 A         HARDREG    DAT    X'18F1'                  HARDNESS CCI REGISTER ADDRESS


                              *                                          TABLE OF % CORRECTIONS TO P FOR
                              *                                          HARDNESS
                              *                                          FIRST ENTRY IS FOR NO CORRECTION
                              *                                          SECOND ENTRY IS FOR SMALLEST
                              *                                          CORRECTION
                              *                                          PERCENT SHOULD BE GREATER THAN 100
                              *                                          ADJUST IN FIELD
      412E  40 1 2E A         HARDTABL   EQU    *
                              *                                          100: NO CORRECTION
412E  0064  00 0 64 A                    DAT    100
412F  0065  00 0 65 A                    DAT    101
4130  0066  00 0 66 A                    DAT    102
4131  0067  00 0 67 A                    DAT    103
4132  0068  00 0 68 A                    DAT    104
4133  0069  00 0 69 A                    DAT    105
4134  006A  00 0 6A A                    DAT    106
4135  006B  00 0 6B A                    DAT    107
4136  006C  00 0 6C A                    DAT    108
4137  006D  00 0 6D A                    DAT    109
                              *
4138  0000  00 0 00 A         INDEXSIZ   DAT    0                        SPEED DIFFERENCE FACTOR
                              *
                              *                                          PROPORTIONAL INTEGRATOR FOR XRAY
                                                                           FEEDBACK
```

AUTOMATIC GAUGE CONTROL

```
4139  003C   00 0 3C A   0559  J2        DAT    60
413A  0078   00 0 78 A   0560  J3        DAT    120
413B  0096   00 0 96 A   0561  J4        DAT    150
                         0562
413C  1040   18 5 40 A   0563  KTABLEP   DAT    KTABLE        POINTER TO K TABLE
                         0564
                         0565  *                              MAX. ALLOWED % CHANGE IN SCREWDOWN
                         0566  *                              (FROM LOCKON). FEEDBACK OCCURS
                         0567  *                              WHEN REF REACHES 'LIMIT'
413D  000A   00 0 0A A   0568  LIMIT     DAT    10
413E  0080   00 0 80 A   0569  LOOPSET   DAT    X'80'
                         0570  *                              MAX INITIAL XRAY DEV BEFORE LOCK
                         0571  *                                -ON OCCURS
413F  000C   00 0 0C A   0572  MAXALLOW  DAT    12
                         0573  *                              MAXIMUN GAGE IN PERCENT
4140  0019   00 0 19 A   0574  MAXGAGE   DAT    25
                         0575  *                              MAX WIDTH OF MILL PRODUCTS
                         0576  *                              IN MILLIMETERS
4141  0A28   08 2 28 A   0577  MAXWIDTH  DAT    2600
4142  0000   00 0 00 A   0578  MONPATOF  DAT    0             MON. HOLD LIGHT OFF CCO PATTERN
4143  0000   00 0 00 A   0579  MONOFPAT  DAT    0             MON. LIGHT OFF CCO PATTERN
                         0580  *                              MON. HOLD CCI REGISTER ADDRESS
4144  18F7   18 0 F7 A   0581  MHOLDREG  DAT    X'18F7'
                         0582  *                              MINIMUM GAGE IN PERCENT
4145  FFE7   F8 7 E7 A   0583  MINGAGE   DAT    -25
                         0584  *                              MONITOR DEADBAND IN %
4146  000A   00 0 0A A   0585  MONDBAND  DAT    10
                         0586  *                              MONITOR ON LIGHT MASK
4147  0800   08 0 00 A   0587  MONONMSK  DAT    X'800'
                         0588  *                              MONITOR ON LIGHT PATTERN
4148  0800   08 0 00 A   0589  MONONPAT  DAT    X'800'
                         0590
4149  4001   40 0 01 A   0591  MONONUM   DAT    X'4001'
                         0592  *                              MONITOR ON LIGHT REGISTER
414A  0004   00 0 04 A   0593  MONONREG  DAT    4
                         0594  *                              NUMBER OF DRIVES
414B  0007   00 0 07 A   0595  NOOFDRVS  DAT    7
                         0596  *                              XRAY MONITOR ON CCI BIT PATTERN
414C  0100   00 1 00 A   0597  ONBITPAT  DAT    X'100'
                         0598  *                              TEMPORARY REFERENCE FOR STRTPOS
414D  0000   00 0 00 A   0599  POSITN    DAT    0
                         0600  *                              NUMBER OF T.D. FOR XRAY SCAN
414E  0004   00 0 04 A   0601  PROGRAMN  DAT    4
                         0602  *                              PULSES PER REVOLUTIONS
414F  0064   00 0 64 A   0603  PULPREV   DAT    100
                         0604  *                              MON. HOLD CCI BIT PATTERN
4150  0200   00 2 00 A   0605  GAGEPAT   DAT    X'200'
                         0606  *                              ESTIMATE OF TIME FOR SCREWS TO POS.
                         0607  *                              IN TENTHS OF SECONDS
4151  000A   00 0 0A A   0608  SCRDELAY  DAT    10
                         0609  *                              FORCE ADJUSTMENT TABLE BASED ON
                         0610  *                                SPEED
      4152   40 1 52 A   0611  SPEEDTAB  EQU    $
4152  0000   00 0 00 A   0612            DAT    0
4153  0000   00 0 00 A   0613            DAT    0
4154  0000   00 0 00 A   0614            DAT    0
4155  0000   00 0 00 A   0615            DAT    0
4156  0000   00 0 00 A   0616            DAT    0
4157  0000   00 0 00 A   0617            DAT    0
                         0618  *                              MON. SELECTED CCI BIT PATTERN
                         0619  *                              (PER STAND BASIS)
4158  1000   10 0 00 A   0620  STDMONBT  DAT    X'1000'
                         0621  *                              THICKNESS CCI REGISTER
4159  18EE   18 0 EE A   0622  THREG1    DAT    X'18EE'
415A  18F0   18 0 F0 A   0623  THREG2    DAT    X'18F0'
                         0624  *                              'MONITIME' TIME FUNCTION
415B  0003   00 0 03 A   0625  TIMEFUNC  DAT    3
                         0626  *                              NUMBER OF ENCODER UNITS PER MILLIMET
415C  0050   00 0 50 A   0627  UNITSPMM  DAT    80
                         0628  *                              WIDTH CORR FACTOR FOR 'K'
415D  0032   00 0 32 A   0629  WFACTR    DAT    50
                         0630  *                              WIDTH CCI REGISTER
415E  1903   18 1 03 A   0631  WIDTHREG  DAT    X'1903'
                         0632  *                              DISTANCE BETWEEN XRAYS IN MM
415F  0096   00 0 96 A   0633  XDIST     DAT    150
                         0634  *                              XRAY 1 MEAS. CCI REGISTER ADDRESS
4160  18F7   18 0 F7 A   0635  XRAY1REG  DAT    X'18F7'
                         0636  *                              XRAY 2 MEAS. CCI REGISTER ADDRESS
4161  18F7   18 0 F7 A   0637  XRAY2REG  DAT    X'18F7'
                         0638  *                              HEAD END DELAY TIME
4162  0004   00 0 04 A   0639  XRHDTIME  DAT    4
                         0640  *                              XRAY 1 SLCT. CCI BIT PATTERN
4163  0400   00 4 00 A   0641  XSELBIT1  DAT    X'400'
                         0642  *                              XRAY 2 SLCT. CCI BIT PATTERN
4164  1000   10 0 00 A   0643  XSELBIT2  DAT    X'1000'
                         0644  *                              XRAY 1 SLCT. CCI REGISTER ADDRESS
4165  18F7   18 0 F7 A   0645  XSELREG1  DAT    X'18F7'
                         0646  *                              XRAY 2 SLCT. CCI REGISTER ADDRESS
4166  18F7   18 0 F7 A   0647  XSELREG2  DAT    X'18F7'
                         0648  *                              XRAY MON. ON CCI REGISTER ADDRESS
4167  18F7   18 0 F7 A   0649  XRONREG   DAT    X'18F7'
                         0650            EJE
                         0651  *
                         0652  *                              THIS DATA IS INTERNAL TO PROGRAM
                         0653  *
                         0654  *                              AGC LIGHT CCO MASK
4168  0000   00 0 00 A   0655  AGCMASK   DAT    0
                         0656  *                              AVERAGE GAUGE DEVIATION
4169  0000   00 0 00 A   0657  AVERDEV   DAT    0
                         0658  *                              AVERAGE MONITOR DEVIATION IN
                         0659  *                              ENCODER UNITS
416A  0000   00 0 00 A   0660  AVERAGER  DAT    0
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AUTOMATIC GAUGE CONTROL

```
                            *                                STAND CALIBRATION STATUS AS DETERMIN
                            *                                BY THE FEEDBACK ROUTINE
416B  0000   00 0 00 A      CAL1      DAT    0
416C  0000   00 0 00 A      CAL2      DAT    0
                            *                                STAND COMPENSATION FACTOR
416D  0000   00 0 00 A      COMPF     DAT    0
                            *                                INTERNAL TABLE INDEX
416E  0000   00 0 00 A      COUNT     DAT    0
                            *                                AVERAGE GAUGE DEVIATION WEIGHT FACTO
416F  0000   00 0 00 A      DEVWEIGF  DAT    0
4170  0000   00 0 00 A      DGE       DAT    0               TEMP STORAGE OF GE DBLE PRECISION
4171  0000   00 0 00 A                DAT    0
                            *                                DRIVE NUMBER CALCULATED BY PROGRAM
4172  0000   00 0 00 A      DRNO      DAT    0
4173  0000   00 0 00 A      FBDEV     DAT    0
4174  0000   00 0 00 A      FILEADR   DAT    0
4175  0000   00 0 00 A      FRSTX     DAT    0
                            *                                NEW GAUGE
4176  0000   00 0 00 A      GAGEREAP  DAT    0
4177  0000   00 0 00 A      GAIN      DAT    0
                            *                                XRAY GAUGE DEVIATION IN ENCODER UNIT
4178  0000   00 0 00 A      GAUGEDEV  DAT    0
                            *                                HARDNESS
4179  0000   00 0 00 A      HARDNESS  DAT    0
                            *                                HEAD END IMPORTANCE WEIGUTING FACTOR
417A  0000   00 0 00 A      HEADWF    DAT    0
417B  0000   00 0 00 A      INDEX     DAT    0
                            *                                GAUGE THICKNESS OF LAST STAND PRODUC
417C  0000   00 0 00 A      LASTSTND  DAT    0
417D  0000   00 0 00 A      LIM0      DAT    0
417E  0000   00 0 00 A      LIM1      DAT    0
417F  0000   00 0 00 A      LIM2      DAT    0
                            *                                LAST STANS STRIP VELOCITY
                            *                                IN METERS /MIN
4180  0000   00 0 00 A      MPMLS     DAT    0
                            *                                MONITOR TRANSPORT TIME DELAY FROM
                            *                                APPLICATION TO TABLE
4181  0000   00 0 00 A      MONITIME  DAT    0
                            *                                NEW MEAN PW
4182  0000   00 0 00 A      NEWMEAN   DAT    0
4183  0000   00 0 00 A      NEWMEAN2  DAT    0
4184  0000   00 0 00 A                DAT    0
4185  0000   00 0 00 A      NEWSIZE   DAT    0
                            *                                NOMINAL GAUGE
4186  0000   00 0 00 A      NOMINAL   DAT    0
                            *                                OLD MEAN PW
4187  0000   00 0 00 A      OLDMEAN   DAT    0
4188  0000   00 0 00 A      OLDMEAN2  DAT    0
4189  0000   00 0 00 A                DAT    0
                            *                                OLD SAMPLE SIZE
418A  0000   00 0 00 A      OLDSIZE   DAT    0
                            *                                LAST STAND REQUIRES FEEDBACK
418B  0000   00 0 00 A      OUTOFLIM  DAT    0
                            *                                PERCENT DEVEATION
418C  0000   00 0 00 A      PRCNTDEV  DAT    0
                            *                                PLASTICITY *WIDTH
418D  0000   00 0 00 A      PW        DAT    0
418E  0000   00 0 00 A                DAT    0
                            *                                K CORRECTION FACTOR
418F  0000   00 0 00 A      PUK       DAT    0
                            *                                RETURN ADDRESS FOR FEEDBACK ROUTINE
4190  0000   00 0 00 A      RETURN    DAT    0
4191  0000   00 0 00 A      SAVEB     DAT    0
                            *                                C REGISTER STORAGE
4192  0000   00 0 00 A      SAVEC     DAT    0
4193  0000   00 0 00 A      SCNDX     DAT    0
                            *                                STAND IMPORTANCE WEIGHTING FACTOR
4194  0000   00 0 00 A      STANDWF   DAT    0
                            *                                TEMPORARY DRIVE NUMBER
4195  0000   00 0 00 A      TEMPDRNO  DAT    0
                            *                                TEMPORARY
4196  0000   00 0 00 A      TEMP      DAT    0
4197  0000   00 0 00 A                DAT    0
4198  0000   00 0 00 A      THICKREG  DAT    0
                            *                                AVERAGE MONITOR DEVIATION
                            *                                WEIGHTING FLAG
4199  0000   00 0 00 A      WF        DAT    0
                            *                                WIDTH OF STRIP
419A  0000   00 0 00 A      WIDTH     DAT    0
419B  0000   00 0 00 A      XTEMP     DAT    0
419C  0000   00 0 00 A                DAT    0
419D  0000   00 0 00 A      FBXRAY    DAT    0
419E  0000   00 0 00 A      FORCEADR  DAT    0
419F  0000   00 0 00 A      KTABLADR  DAT    0


41A0                                  RES    9
                                      EJE
                            *                                SHIFT LEFT ARITHMETIC
      0000   00 0 00 A      SLA       EQU    0
                            *                                SHIFT RIGHT ARITHMETIC
      4000   40 0 00 A      SRA       EQU    X'4000'
                            *                                DOUBLE LEFT ARITHMETIC
      8000   80 0 00 A      DLA       EQU    X'8000'
      C000   C0 0 00 A      DRA       EQU    X'C000'         DOUBLE RIGHT ARITHMETIC

      0004   00 0 04 A      MOO       EQU    4
      00B0   00 0 B0 A      K:X1      EQU    X'B0'
      00B1   00 0 B1 A      K:X2      EQU    X'B1'
      00AC   00 0 AC A      K:X3      EQU    X'AC'
      00B2   00 0 B2 A      K:X4      EQU    X'B2'
      00AD   00 0 AD A      K:X5      EQU    X'AD'
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AUTOMATIC GAUGE CONTROL

```
         00A8   00 0 A8 A   0763  K:X6      EQU   X'A8'
         00AE   00 0 AE A   0764  K:X7      EQU   X'AE'
         00B3   00 0 B3 A   0765  K:X8      EQU   X'B3'
         00AF   00 0 AF A   0766  K:X9      EQU   X'AF'
         00B4   00 0 B4 A   0767  K:X10     EQU   X'B4'
         00B5   00 0 B5 A   0768  K:X20     EQU   X'B5'
         00A2   00 0 A2 A   0769  K:XFF     EQU   X'A2'
         00A0   00 0 A0 A   0770  K:XFFFF   EQU   X'A0'
         0048   00 0 48 A   0771  DTAFLES   EQU   X'48'
         0049   00 0 49 A   0772  TMDLYTBL  EQU   X'49'
         004C   00 0 4C A   0773  MESSAGE   EQU   X'4C'
         0029   00 0 29 A   0774  S:CC0     EQU   X'29'
         0036   00 0 36 A   0775  GRAYBIN   EQU   X'36'
         0038   00 0 38 A   0776  STRTP0S   EQU   X'38'
         002E   00 0 2E A   0777  TWHEX     EQU   X'2E'
                            0778  *                          ACTUAL THICKNESS
                            0779  *                          VALUE IS IN MILLIMETERS*100
         0090   00 0 90 A   0780  XRAY      EQU   X'90'
                            0781  *                          DEVICE NUMBER
         0091   00 0 91 A   0782  XRAYN0    EQU   X'91'
                            0783  *                          NUMBER OF POINT SCANNED
         0092   00 0 92 A   0784  SCANNUM   EQU   X'92'
         0064   00 0 64 A   0785  HEADGAGE  EQU   X'64'
                            0786            EJE
                            0787  *                          INDEX DATA POOL WITH B
                            0788  *
41A9     0A27   08 2 27 A   0789  BEGIN     LDB   =D
41AA     3004   30 0 04 A   0790            CDR   M00
         410F   40 1 0F A   0791            BSB   D
                            0792  *                          DETERMINE DRIVE NUMBER
                            0793
                            0794  *                          ANALOG SCAN PROG HAS STORED DRIVE
                            0795  *                          NUMBER IN 'SCANNUM'.  IT IS A1 -
                            0796  *                          8 WHERE 8 REPRESENTS THE XRAY
41AB     2892   28 0 92 A   0797            LDA   SCANNUM
41AC     AAC6   A8 2 C6 A   0798            STA   DRN0
                            0799
41AD     2C04   28 5 04 A   0800            LDA   *AGCMREG
41AE     5C06   58 4 06 A   0801            AND   BITPAT1
                            0802  *                          IS AGC MASTER ON   NO; ZJP N0G00DX
                            0803  *                          AND TURN OFF AGC LIGHTS
41AF     F215   F0 2 15 A   0804            ZJP   N0G00DX
41B0     2AC2   28 2 C2 A   0805            LDA   DRN0
41B1     48B3   48 0 B3 A   0806            SUB   K:X8
                            0807  *                          IS THIS THE XRAY   YES; PJP XRAYPR
41B2     B31F   B0 3 1F A   0808            PJP   XRAYPR
                            0809  *                          SELECT MASK
41B3     2A1F   28 2 1F A   0810            LDA   =SLA
41B4     42BE   40 2 BE A   0811            ADD   DRN0
41B5     48B0   48 0 B0 A   0812            SUB   K:X1
41B6     A803   A8 0 03 A   0813            STA   G
41B7     28B0   28 0 B0 A   0814            LDA   K:X1
41B8     9805   98 0 05 A   0815            SHF   A
                            0816  *                          MASK FOR THIS STAND'S AGC LIGHT
41B9     AAAF   A8 2 AF A   0817            STA   AGCMASK
                            0818  *                          PUT STARTING ADDRESS OF DRIVE FILE
                            0819  *                          IN C REGISTER
41BA     2848   28 0 48 A   0820            LDA   DTAFLES
41BB     4AB7   48 2 B7 A   0821            SUB   DRN0
41BC     1105   10 1 05 A   0822            LDC   *A
41BD     2905   28 1 05 A   0823            LDA   *A
41BE     AAD4   A8 2 D4 A   0824            STA   SAVEC
         1000   10 0 00 A   0825            BSC   FILE
                            0826  *                          IS ROLL FORCE SELECTED
41BF     2E23   28 6 23 A   0827            LDA   MCI
41C0     6005   60 0 05 A   0828            INC   A
41C1     2905   28 1 05 A   0829            LDA   *A
41C2     5C07   58 4 07 A   0830            AND   BITPAT2
41C3     F204   F0 2 04 A   0831            ZJP   N0G00D
41C4     720F   70 2 0F A   0832            JMP   CHKAUT0
                            0833
         41C5   40 1 C5 A   0834  N0G00DX   EQU   $
41C5     2C02   28 4 02 A   0835            LDA   AGCPAT
41C6     AAA2   A8 2 A2 A   0836            STA   AGCMASK
41C7     7201   70 2 01 A   0837            JMP   N0G00D+1
         41C8   40 1 C8 A   0838  N0G00D    EQU   $
                            0839  *                          AGC LOCKS ON AFTER MAN INTERVENTION
41C8     3E58   38 6 58 A   0840            STZ   HEADEND
                            0841  *                          TURN OFF AGC LIGHT(S) BY OUTPUTING
                            0842  *                          ZEROS
41C9     ED29   E8 5 29 A   0843            SST   *S:CC0,B
41CA     0C01   00 0 01 A   0844            DAT   AGCNUM-D
41CB     0C05   00 0 05 A   0845            DAT   AGCPAT1-D
41CC     0003   00 0 03 A   0846            DAT   AGCREG-D
41CD     0059   00 0 59 A   0847            DAT   AGCMASK-D
41CE     EDE7   E8 5 E7 A   0848  END       SST   *EXIT,B
41CF     7209   70 2 D9 A   0849            JMP   BEGIN
41D0     410F   40 1 0F A   0850            LPL
41D1     43E1   40 3 E1 A
41D2     0000   00 0 00 A
41D3     41D3   40 1 D3 A
                            0851            EJE
                            0852  *                          IS AUTO SELECTED FOR THE STAND
         41D4   40 1 D4 A   0853  CHKAUT0   EQU   $
41D4     2E23   28 6 23 A   0854            LDA   MCI
41D5     6005   60 0 05 A   0855            INC   A
41D6     2905   28 1 05 A   0856            LDA   *A
41D7     5C08   58 4 08 A   0857            AND   BITPAT3
41D8     F2EF   F0 2 EF A   0858            ZJP   N0G00D
                            0859  *                          ARE SCREWS CALIBRATED
                            0860  *                          NO:  ZJP  N0G00D
41D9     2E11   28 6 11 A   0861            LDA   CALFLAG
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AUTOMATIC GAUGE CONTROL

```
41DA  B2ED   80 2 ED A            PJP    NOGOOD
                             *                        IS STRIP IN STAND FLAG SET
                             *                        NO:  ZJP  END
41DB  2E27   28 6 27 A            LDA    SIS
41DC  F2F1   F0 2 F1 A            ZJP    END
                             *                        IS THIS FIRST SCAN ON STRIP
                             *                        NO:  NJP  NOTHEAD
41DD  2E5B   28 6 5B A            LDA    HEADEND
41DE  BA55   B8 2 55 A            NJP    NOTHEAD
                             *                        THIS IS FIRST SCAN
41DF  3E5B   38 6 5B A            STZ    HEADEND
                             *                        SET 'HEAD END WAS PROCESSED' FLAG
41E0  6E5B   68 6 5B A            DCR    HEADEND
                             *                        SAVE SCREWDOWN LOCK ON
                             *                        READ ENCODER
41E1  ED36   E8 5 36 A            SST    *GRAYBIN,B
                             *                        STORE VALUE
41E2  AE87   A8 6 87 A            STA    SDLO
                             *                        SAVE LOCK ON SPEED
41E3  2E8D   28 6 8D A            LDA    SPEED
41E4  AE40   A8 6 40 A            STA    SPEEDLO
                             *                        SAVE LOCK ON FORCE (METRIC TONS)
41E5  2E4B   28 6 4B A            LDA    ANFORCE
41E6  AE56   A8 6 56 A            STA    FORCELO
                             *                        SAVE REAL SCREWDOWN LOCKON
41E7  2EA0   28 6 A0 A            LDA    FXDOFF
41E8  D44D   D0 4 4D A            MPY    UNITSPMM
41E9  DA48   D8 2 48 A            DIV    =100
41EA  4687   40 6 87 A            ADD    SDLO
41EB  AE3F   A8 6 3F A            STA    REALSDLO

41EC  2A86   28 2 86 A            LDA    DRNO
41ED  6805   68 0 05 A            DCR    A
41EE  DCA6   D0 0 A6 A            MPY    K;X6
41EF  A804   A8 0 04 A            STA    E
41F0  440B   40 4 0B A            ADD    FORCEP                FIND FORCE TABLE
41F1  AAAD   A8 2 AD A            STA    FORCEADR
41F2  2C2D   28 4 2D A            LDA    KTABLEP
41F3  4C04   40 0 04 A            ADD    E
41F4  AAAB   A8 2 AB A            STA    KTABLADR
                             *
                             *                        CALCULATE THE K
                             *
                             *                        LOOK UP K FOR THIS FORCE
41F5  3C5F   38 4 5F A            STZ    COUNT
41F6  2AA8   28 2 A8 A   LARGERF  LDA    FORCEADR
                             *                        FORCE 1 IS SMALLEST FORCE IN THIS
                             *                        DRIVE'S SECTION OF FORCE TABLE
41F7  445F   40 4 5F A            ADD    COUNT
41F8  2905   28 1 05 A            LDA    *A
41F9  4E56   48 6 56 A            SUB    FORCELO
                             *                        IS TABLE FORCE EXCEEDED
                             *                        YES:  PJP  THISFORC
41FA  B207   80 2 07 A            PJP    THISFORC
41FB  645F   60 4 5F A            INC    COUNT
41FC  2C5F   28 4 5F A            LDA    COUNT
41FD  48AD   48 0 AD A            SUB    K;X5
41FE  B201   80 2 01 A            PJP    $+2
41FF  72F6   70 2 F6 A            JMP    LARGERF
4200  28AD   28 0 AD A            LDA    K;X5
4201  AC5F   A8 4 5F A            STA    COUNT
                             *                        LOOK UP K IN TABLE
4202  2A9D   28 2 9D A   THISFORC LDA    KTABLADR
4203  445F   40 4 5F A            ADD    COUNT
4204  2905   28 1 05 A            LDA    *A
4205  AE5D   A8 6 5D A            STA    K
                             *
                             *                        CORRECT K FOR WIDTH OF STRIP
                             *                        K=K-WFACTR+(W*WFACTR/MAXWIDTH)
                             *
                             *                        READ WIDTH
4206  244F   20 4 4F A            LDE    WIDTHREG
4207  2892   28 0 92 A            LDA    K;X4
4208  ED2E   E8 5 2E A            SST    *TWHEX,B
                             *                        WIDTH STORED IN MILLIMETERS
4209  AA91   A8 2 91 A            STA    WIDTH
420A  D44E   D0 4 4E A            MPY    WFACTR
                             *                        DIVIDE BY MAXIMUM PRODUCT WIDTH
                             *                        IN MILLIMETERS
420B  DC32   D8 4 32 A            DIV    MAXWIDTH
420C  4C4E   48 4 4E A            SUB    WFACTR
420D  465D   40 6 5D A            ADD    K
420E  AE5D   A8 6 5D A            STA    K
                             *                        PICK UP PLASTICITY FROM TABLE
                             *
                             *                        DETERMINE GAUGE CLASS
420F  3C5F   38 4 5F A            STZ    COUNT
4210  2E42   28 6 42 A   LARGERC  LDA    CLASS1
                             *                        CLASS1 IS ADDRESS OF CLASS TABLE
                             *                          FOR THIS DRIVE
4211  445F   40 4 5F A            ADD    COUNT
4212  2905   28 1 05 A            LDA    *A
4213  4E87   48 6 87 A            SUB    SDLO
                             *                        IS TABLE GAUGE EXCEEDED
                             *                        YES:  PJP  THISCLAS
4214  B207   80 2 07 A            PJP    THISCLAS
4215  645F   60 4 5F A            INC    COUNT
4216  2C5F   28 4 5F A            LDA    COUNT
4217  48AE   48 0 AE A            SUB    K;X7
4218  B201   80 2 01 A            PJP    $+2
4219  72F6   70 2 F6 A            JMP    LARGERC
421A  28AE   28 0 AE A            LDA    K;X7
421B  AC5F   A8 4 5F A            STA    COUNT
```

AUTOMATIC GAUGE CONTROL

```
                             *                                LOOK UP P IN TABLE
                             *                                THERE ARE 8 VALUES IN 'PTABLE'
       421C    40 2 1C A     THISCLAS EQU      $
                             *                                CONVERT WIDTH TO ENCODER UNITS

                             *                                ADDRESS OF FIRST PTABLE VALUE
421C   2E69    28 6 69 A              LDA      PTABLE
                             *                                COUNT IS 0 - 7
421D   445F    40 4 5F A              ADD      COUNT
421E   2905    28 1 05 A              LDA      *A
421F   D212    D0 2 12 A              MPY      =100
4220   DC88    D8 4 88 A              DIV      WIDTH
4221   AE66    A8 6 66 A              STA      PLAST
                             *                                CORRECT FOR HARDNESS
4222   2D1E    28 5 1E A              LDA      *HARDREG
4223   5C1D    58 4 1D A              AND      HARDBITS
4224   1A0E    18 2 0E A              LDS      =SRA+4
4225   9805    98 0 05 A              SHF      A
4226   AC6A    A8 4 6A A              STA      HARDNESS
4227   2A0C    28 2 0C A              LDA      =HARDTABL
4228   446A    40 4 6A A              ADD      HARDNESS
4229   2905    28 1 05 A              LDA      *A
422A   AC6A    A8 4 6A A              STA      HARDNESS
                             *                                HARDNESS IS IN %
422B   2E66    28 6 66 A              LDA      PLAST
422C   D205    D0 2 05 A              MPY      =100
422D   DC6A    D8 4 6A A              DIV      HARDNESS
422E   AE66    A8 6 66 A              STA      PLAST
422F   7204    70 2 04 A              JMP      NOTHEAD
4230   4233    40 2 33 A              LPL
4231   0064    00 0 64 A
4232   4C04    40 0 04 A
4233   412E    40 1 2E A
                                      EJE
                             *                                THIS IS START OF AGC MAIN PATH
                             *


       4234    40 2 34 A     NOTHEAD  EQU      $
                             *                                READ PRESENT SCREW POSITION
4234   ED36    E8 5 36 A              SST      *GRAYBIN,B
4235   AE89    A8 6 89 A              STA      SCREW
                             *                                DID LOAD CELL TEST PROPERLY
                             *                                YES: ZJP GAUGERR
4236   2E2A    28 6 2A A              LDA      NOTCALIB
4237   F202    F0 2 02 A              ZJP      GAUGERR
                             *                                CONTINUE IF NOT CALIBRATED BUT
                             *                                DO NOT MOVE SCREW TO CORRECT GAUGE
4238   3E51    38 6 51 A              STZ      DELTAS
4239   7348    70 3 48 A              JMP      CHKFDBK
                             *                                STAND CALIBRATED
       423A    40 2 3A A     GAUGERR  EQU      $
                             *                                CALCULATE GAUGE ERROR
                             *                                GE=(F-FLO-SP)*K+S-SLO+FEEDOUT+OTHER

                             *                                DETERMINE SPEED ADJUSTMENT
423A   2E8D    28 6 8D A              LDA      SPEED
423B   4E40    48 6 40 A              SUB      SPEEDLO
423C   D429    D0 4 29 A              MPY      INDEXSIZ
423D   DE40    D8 6 40 A              DIV      SPEEDLO
423E   BA08    B8 2 08 A              NJP      INDEXO
423F   4A43    48 2 43 A              SUB      =5
4240   B203    B0 2 03 A              PJP      $+4
4241   4241    40 2 41 A              ADD      =5
4242   AC6C    A8 4 6C A              STA      INDEX
4243   7204    70 2 04 A              JMP      $+5
4244   2A3E    28 2 3E A              LDA      =5
4245   AC6C    A8 4 6C A              STA      INDEX
4246   7201    70 2 01 A              JMP      $+2
4247   3C6C    38 4 6C A     INDEXO   STZ      INDEX
                             *                                PICK UP SPEED ADJUSTMENT FROM
                             *                                  TABLE
4248   2A38    28 2 38 A              LDA      =SPEEDTAB
4249   446C    40 4 6C A              ADD      INDEX
424A   2905    28 1 05 A              LDA      *A
424B   A804    A8 0 04 A              STA      E
424C   2E4B    28 6 4B A              LDA      ANFORCE
424D   4E56    48 6 56 A              SUB      FORCELO
424E   4804    48 0 04 A              SUB      E
424F   D65D    D0 6 5D A              MPY      K
                             *                                CONVERT ANFORCE AND FORCELO TO
                             *                                KILOTONS
4250   DA33    D8 2 33 A              DIV      =1000
4251   4689    40 6 89 A              ADD      SCREW
4252   4E87    48 6 87 A              SUB      SDLO
4253   4653    40 6 53 A              ADD      FEEDOUT
4254   4665    40 6 65 A              ADD      OTHER
4255   AE5A    A8 6 5A A              STA      GE                   GAUGE ERROR

                             *                                CALC SCREW CORRECTION 'DELTAS'
                             *                                DELTAS=GE*(1+K/P)=GE+GE*K/P
4256   D65D    D0 6 5D A              MPY      K
4257   DE66    D8 6 66 A              DIV      PLAST
4258   465A    40 6 5A A              ADD      GE
4259   AE51    A8 6 51 A              STA      DELTAS
425A   B202    B0 2 02 A              PJP      CHCKSIZE
       425B    40 2 5B A     NEGDELT  EQU      $
425B   3805    38 0 05 A              STZ      A
425C   4E51    48 6 51 A              SUB      DELTAS
                             *
                             *                                SCREW CORRECTION
                             *
                             *                                IF SCREW CORRECTION IS VERY SMALL,
                             *                                IGNORE IT I.E. WITHIN DEADBAND
```

AUTOMATIC GAUGE CONTROL

```
      425D  40 2 5D A   CHCKSIZE EQU  $
425D  4E50  48 6 50 A            SUB  DEADBAND
425E  B202  B0 2 02 A            PJP  AVERAGE
      425F  40 2 5F A   TOOSMALL EQU  $
                        *                              GAUGE ERROR IS TOO SMALL
425F  3E5A  38 6 5A A            STZ  GE
4260  3E51  38 6 51 A            STZ  DELTAS
                        *                              CALCULATE AVERAGE ERROR FOR USE BY
                        *                              FEEDBACK ROUTINE
4261  2E5A  28 6 5A A   AVERAGE  LDA  GE
4262  D080  D0 0 80 A            MPY  K:X1
4263  A461  A0 4 61 A            STE  DGE
4264  AC62  A8 4 62 A            STA  DGE+1
4265  2E4C  28 6 4C A            LDA  AVERR
4266  DE4A  D8 6 4A A            MPY  AGCWF
4267  C461  C0 4 61 A            ADA  DGE
4268  664A  60 6 4A A            INC  AGCWF
4269  DE4A  D8 6 4A A            DIV  AGCWF
426A  AE4C  A8 6 4C A            STA  AVERR
426B  AC64  A8 4 64 A            STA  FBDEV
426C  2E4A  28 6 4A A            LDA  AGCWF
426D  48AD  48 0 AD A            SUB  K:X5
426E  BA02  B8 2 02 A            NJP  $+3
426F  28AD  28 0 AD A            LDA  K:X5
4270  AE4A  A8 6 4A A            STA  AGCWF
                        *
                        *
                        *                              IF CHANGE IN SCREW POSITION IS
                        *                              TOO LARGE, LIMIT IT
4271  2E51  28 6 51 A            LDA  DELTAS
4272  4E3E  48 6 3E A            SUB  MAXDELTA
4273  B205  B0 2 05 A            PJP  POSLIMIT
4274  2E3E  28 6 3E A            LDA  MAXDELTA
4275  4651  40 6 51 A            ADD  DELTAS
4276  BA05  B8 2 05 A            NJP  NEGLIMIT
                        *                              NO SKID MARK IN THIS STAND SINCE
                        *                              DELTAS IS WITHIN LIMITS
4277  3E58  38 6 58 A            STZ  FRSTSKID
                        *                              JUMP TO SKID APPROACH
4278  7243  70 2 43 A            JMP  SKIDAPRO
      4279  40 2 79 A   POSLIMIT EQU  $
4279  2E51  28 6 51 A            LDA  DELTAS
427A  A804  A8 0 04 A            STA  E
427B  720A  70 2 0A A            JMP  FEEDFWD
      427C  40 2 7C A   NEGLIMIT EQU  $
427C  3805  38 0 05 A            STZ  A
427D  4E51  48 6 51 A            SUB  DELTAS
427E  A804  A8 0 04 A            STA  E
427F  7206  70 2 06 A            JMP  FEEDFWD
4280  4152  40 1 52 A            LPL
4281  42D7  40 2 D7 A
4282  0005  00 0 05 A
4283  03E8  00 3 E8 A
4284  4285  40 2 85 A
4285  428B  40 2 8B A
                                 EJE
                        *                              FEED FORWARD ROUTINE
      4286  40 2 86 A   FEEDFWD  EQU  $
                        *                              IF LAST STAND DO NOT FEED FORWARD
                        *                              JUMP TO SKID APPROACH
4286  2C63  28 4 63 A            LDA  DRNO
4287  4C3C  48 4 3C A            SUB  NOOFDRVS
4288  B233  B0 2 33 A            PJP  SKIDAPRO
4289  2848  28 0 48 A            LDA  DTAFLES
428A  4C63  48 4 63 A            SUB  DRNO
428B  6805  68 0 05 A            DCR  A
                        *                              STORE POINTER TO NEXT DRIVE'S
                        *                                DATA FILE IN 'G'
428C  1905  18 1 05 A            LDG  *A
428D  7206  70 2 06 A            JMP  SKIDMARK
                        *                              BACK OF SKID MARK, INC LENGTH COUNT
428E  1003  10 0 03 A   INSKID   LDC  G
428F  668C  60 6 8C A            INC  SKIDSIZE
                        *                              UPDATE SIZE OF SKID
4290  1483  10 4 83 A            LDC  SAVEC
4291  2804  28 0 04 A            LDA  E
4292  AE8B  A8 6 8B A            STA  SKIDS
4293  7228  70 2 28 A            JMP  SKIDAPRO
      4294  40 2 94 A   SKIDMARK EQU  $
4294  2E58  28 6 58 A            LDA  FRSTSKID
                        *                              IS THIS FIRST SIGN OF SKIDMARK
                        *                              NO:  NJP INSKID
4295  BAF8  B8 2 F8 A            NJP  INSKID
4296  1003  10 0 03 A            LDC  G
                        *                              STORE 1 IN SKID COUNTER
4297  2881  28 0 81 A            LDA  K:X2
4298  AE8C  A8 6 8C A            STA  SKIDSIZE
4299  1483  10 4 83 A            LDC  SAVEC
429A  3E58  38 6 58 A            STZ  FRSTSKID
429B  6E58  68 6 58 A            DCR  FRSTSKID
                        *                              SET FLAG FOR SKID UP OR SKID DOWN
429C  2E51  28 6 51 A            LDA  DELTAS
429D  1003  10 0 03 A            LDC  G
429E  3E62  38 6 62 A            STZ  MOVEUP
429F  2805  28 0 05 A            LDA  A
42A0  BA01  B8 2 01 A            NJP  TRANTIME
42A1  6E62  68 6 62 A            DCR  MOVEUP
                        *                              CALCULATE TRANSPORT TIME DELAY
                        *                              DISTANCE FROM THIS STAND TO NEXT
```

AUTOMATIC GAUGE CONTROL

```
        42A2   40 2 A2 A   TRANTIME EQU   $
42A2    1483   10 4 83 A            LDC   SAVEC
42A3    3604   38 0 04 A            STZ   E
42A4    2E8A   28 6 8A A            LDA   SEPARATE
42A5    DE8D   D8 6 8D A            DIV   SPEED
42A6    3604   38 0 04 A            STZ   E
42A7    D212   D0 2 12 A            MPY   =600
42A8    DE4E   D8 6 4E A            DIV   CIRCUM
42A9    A803   A8 0 03 A            STA   G
42AA    2848   28 0 48 A            LDA   DTAFLES
42AB    4C63   48 4 63 A            SUB   DRN8
42AC    6805   68 0 05 A            DCR   A
42AD    1105   10 1 05 A            LDC   *A
42AE    2849   28 0 49 A            LDA   TMDLYTBL
42AF    420B   40 2 0B A            ADD   =X'25'
42B0    4463   40 4 63 A            ADD   DRN8
42B1    6005   60 0 05 A            INC   A
42B2    A404   A8 0 04 A            STA   E
42B3    2803   28 0 03 A            LDA   G
42B4    4C0A   48 4 0A A            SUB   DELAY
42B5    A904   A8 1 04 A            STA   *E
42B6    3E54   38 6 54 A            STZ   FEEDTIME
42B7    1483   10 4 83 A            LDC   SAVEC
                                *                          COUNTED DOWN BY PERIODIC PROGRAM
42B8    7271   70 2 71 A            JMP   CALCREF
42B9    0258   00 2 58 A            LPL
42BA    0025   00 0 25 A
42BB    4329   40 3 29 A
                                *                          IS SKID MARK APPROACHING
        42BC   40 2 BC A   SKIDAPRO EQU   $
                                *                          TRANSPORT TIMER FLAG
42BC    2C63   28 4 63 A            LDA   DRN8
42BD    6805   68 0 05 A            DCR   A
42BE    F219   F0 2 19 A            ZJP   CHKFDBK
42BF    2E54   28 6 54 A            LDA   FEEDTIME
42C0    F217   F0 2 17 A            ZJP   CHKFDBK
                                *                          NONE APPROACHING, CHECK IF ANY
                                *                          IN STAND
42C1    B213   B0 2 13 A            PJP   INSTAND
                                *                          IS SKID MARK CLOSE ENOUGH TO
                                *                          REQUIRE MOVING SCREWS
                                *                          IS THIS A BUMP OR DIP TYPE SKID
42C2    3E54   38 6 54 A   BUMPDIP  STZ   FEEDTIME
42C3    6654   60 6 54 A            INC   FEEDTIME
42C4    2E62   28 6 62 A            LDA   MOVEUP
42C5    BA03   B8 2 03 A            NJP   MOVEDN
                                *                          MOVE UP
42C6    2A32   28 2 32 A            LDA   =-20
42C7    AE51   A8 6 51 A            STA   DELTAS
42C8    7202   70 2 02 A            JMP   FINDEND
                                *                          MOVE DOWN
        42C9   40 2 C9 A   MOVEDN   EQU   $
42C9    2A2E   28 2 2E A            LDA   =20
42CA    AE51   A8 6 51 A            STA   DELTAS

        42CB   40 2 CB A   FINDEND  EQU   $
42CB    6E8C   68 6 8C A            DCR   SKIDSIZE
                                *                          IS SKID MARK ALMOST ALL THE WAY THRU
                                *                          YES:  ZJP  ENDOFSKD
42CC    F201   F0 2 01 A            ZJP   ENDOFSKD
                                *                          SKID MARK IS STILL IN STAND
42CD    725C   70 2 5C A            JMP   CALCREF
                                *                          SKID MARK IS THROUGH, REMOVE
                                *                          OFFSET
        42CE   40 2 CE A   ENDOFSKD EQU   $
42CE    2E62   28 6 62 A            LDA   MOVEUP
42CF    BA02   B8 2 02 A            NJP   $+3
42D0    2A27   28 2 27 A            LDA   =20
42D1    7201   70 2 01 A            JMP   $+2
42D2    2A26   28 2 26 A            LDA   =-20
42D3    AE51   A8 6 51 A            STA   DELTAS
42D4    7255   70 2 55 A            JMP   CALCREF
                                *                          IS A SKID MARK IN STAND
42D5    2E8C   28 6 8C A   INSTAND  LDA   SKIDSIZE
42D6    F201   F0 2 01 A            ZJP   CHKFDBK
                                *                          NO, CHECK FOR FEEDBACK
42D7    B2F3   B0 2 F3 A            PJP   FINDEND
                                *                          YES
        42D8   40 2 D8 A   CHKFDBK  EQU   $
42D8    3E5E   38 6 5E A            STZ   LIMFLAG
42D9    2E89   28 6 89 A            LDA   SCREW
42DA    4E51   48 6 51 A            SUB   DELTAS
42DB    AE68   A8 6 68 A            STA   POSITION
42DC    4E87   48 6 87 A            SUB   SDL8
                                *                          IS THIS POSITION OUT OF LIMIYS
42DD    D219   D0 2 19 A            MPY   =100
42DE    DE3F   D8 6 3F A            DIV   REALSDL8
42DF    A604   A8 0 04 A            STA   E
42E0    4C2E   48 4 2E A            SUB   LIMIT
                                *                          LIMIT IS EXPRESSED IN PERCENT
42E1    B21A   B0 2 1A A            PJP   SETFLAGU
42E2    2804   28 0 04 A            LDA   E
42E3    442E   40 4 2E A            ADD   LIMIT
42E4    BA1B   B8 2 1B A            NJP   SETFLAGD
42E5    F21A   F0 2 1A A            ZJP   SETFLAGD
                                *                          IS PREVIOUS STAND LOAD CELL ON
42E6    2463   20 4 63 A            LDE   DRN8
42E7    6804   68 0 04 A            DCR   E
42E8    F241   F0 2 41 A            ZJP   CALCREF
42E9    2848   28 0 48 A            LDA   DTAFLES
42EA    4804   48 0 04 A            SUB   E
42EB    1105   10 1 05 A            LDC   *A
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AUTOMATIC GAUGE CONTROL

```
42EC  2E2A   28 6 2A A              LDA      NOTCALIB
42ED  AC67   A8 4 67 A              STA      TEMP
42EE  1483   10 4 83 A              LDC      SAVEC
42EF  2C67   28 4 87 A              LDA      TEMP
42F0  6005   60 0 05 A              INC      A
42F1  F201   F0 2 01 A              ZJP      $+2             IS L.C. OFF
42F2  7237   70 2 37 A              JMP      CALCREF
                           *                                 IS THIS STAND LOAD CELL ON
42F3  2E2A   28 6 2A A              LDA      NOTCALIB
42F4  F20E   F0 2 0E A              ZJP      FEEDBACK
42F5  7234   70 2 34 A              JMP      CALCREF
42F6  0064   00 0 64 A              LPL
42F7  0014   00 0 14 A
42F8  FFEC   F8 7 EC A
42F9  42F5   40 2 F5 A
42FA  42FF   40 2 FF A
42FB  4302   40 3 02 A
                                    EJE
                           *                                 FEEDBACK ROUTINE
                           *                                 IS STAND BEFORE THIS DISQUALIFIED
                           *                                 SET FLAG TO INDICATE UP LIMIT
42FC  3805   38 0 05 A     SETFLAGU STZ      A
42FD  6005   60 0 05 A              INC      A
42FE  AE5E   A8 6 5E A              STA      LIMFLAG
42FF  7203   70 2 03 A              JMP      FEEDBACK
                           *                                 SET FLAG TO INDICATE DOWN LIMIT
4300  3805   38 0 05 A     SETFLAGD STZ      A
4301  6805   68 0 05 A              DCR      A
4302  AE5E   A8 6 5E A              STA      LIMFLAG
                           *                                 CAN STAND BEHIND THIS MOVE
      4303   40 3 03 A     FEEDBACK EQU      $
4303  2C63   28 4 63 A              LDA      DRNO
4304  6805   68 0 05 A              DCR      A
4305  F223   F0 2 23 A              ZJP      FBRET1
4306  2848   28 0 48 A              LDA      DTAFLES
4307  4C63   48 4 63 A              SUB      DRNO
4308  6005   60 0 05 A              INC      A
4309  AC65   A8 4 65 A              STA      FILEADR
                           *                                 ADDRESS OF FILE FOR STAND BEHIND THI
430A  3C5C   38 4 5C A              STZ      CAL1
430B  2E11   28 6 11 A              LDA      CALFLAG
430C  BA01   B8 2 01 A              NJP      $+2
430D  6C5C   68 4 5C A              DCR      CAL1
                           *                                 IF ZERO SET A NOTCALIB. FLAG
      430E   40 3 0E A     ZEROSTD  EQU      $
430E  2E5E   28 6 5E A              LDA      LIMFLAG
                           *                                 IS THE PROBLEM LACK OF RF SIGNAL
430F  F207   F0 2 07 A              ZJP      CHKRF
                           *                                 IS N-1 CALIBRATED
4310  2C5C   28 4 5C A              LDA      CAL1
                           *                                 CONTINUE IF YES
4311  6005   60 0 05 A              INC      A
4312  F216   F0 2 16 A              ZJP      FBRET1
4313  7208   70 2 08 A              JMP      OUTPUT
4314  4328   40 3 28 A              LPL
4315  4316   40 3 16 A
4316  431B   40 3 1B A
                           *                                 FEEDBACK TO STAND WITH BAD R F SIGNAL
      4317   40 3 17 A     CHKRF    EQU      $
                           *                                 ADDRESS OF FILE FOR STAND N-1
4317  1565   10 5 65 A              LDC      *FILEADR
                           *                                 IS ROLL FORCE OK
4318  2E2A   28 6 2A A              LDA      NOTCALIB
4319  6005   60 0 05 A              INC      A
431A  F201   F0 2 01 A              ZJP      OUTPUT
431B  720D   70 2 0D A              JMP      FBRET1

      431C   40 3 1C A     OUTPUT   EQU      $
                           *                                 SAVE CORRECTION IN 'FEEDOUT' FOR
                           *                                   INCLUSION IN NEW POSITION REF
431C  1483   10 4 83 A              LDC      SAVEC
431D  2E5A   28 6 5A A              LDA      GE
431E  D68D   D0 6 8D A              MPY      SPEED
431F  1565   10 5 65 A              LDC      *FILEADR
4320  DE8D   D8 6 8D A              DIV      SPEED
4321  D69C   D0 6 9C A              MPY      L1
4322  DE9D   D8 6 9D A              DIV      L2
4323  A803   A8 0 03 A              STA      G
4324  2E53   28 6 53 A              LDA      FEEDOUT
4325  D69E   D0 6 9E A              MPY      L3
4326  DE9F   D8 6 9F A              DIV      L4
4327  4003   40 0 03 A              ADD      G
4328  AE53   A8 6 53 A              STA      FEEDOUT

      4329   40 3 29 A     FBRET1   EQU      $
4329  1483   10 4 83 A              LDC      SAVEC
                           *                                 CALCULATE AND LIMIT REFERENCE
      432A   40 3 2A A     CALCREF  EQU      $
                           *                                 IS TAIL END COMPENSATION REQUESTED
432A  2E97   28 6 97 A              LDA      TAILCOMP
432B  F20F   F0 2 0F A              ZJP      CALCPOS
                           *                                 HAS TRANSPORT TIME ELAPSED
432C  2E98   28 6 98 A              LDA      TAILTIME
432D  F20D   F0 2 0D A              ZJP      CALCPOS
                           *                                 YES, IS THIS FULL COMPENSATION
432E  2E97   28 6 97 A              LDA      TAILCOMP
432F  6005   60 0 05 A              INC      A
4330  F205   F0 2 05 A              ZJP      FULLCOMP
                           *                                 2/3 COMPENSATION REQUESTED
4331  2E4F   28 6 4F A              LDA      COMPEN
4332  D081   D0 0 81 A              MPY      K1X2
4333  D8AC   D8 0 AC A              DIV      K1X3
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AUTOMATIC GAUGE CONTROL

```
4334  4689   40 6 89 A   1358           ADD   SCREW
4335  7206   70 2 06 A   1359           JMP   CALCPOS1
4336  2E4F   28 6 4F A   1360 FULLCOMP  LDA   COMPEN
4337  4689   40 6 89 A   1361           ADD   SCREW
4338  7203   70 2 03 A   1362           JMP   CALCPOS1
4339  433A   40 3 3A A   1363           LPL
433A  433B   40 3 3B A
433B  2E89   28 6 89 A   1364 CALCPOS   LDA   SCREW
433C  4E51   48 6 51 A   1365 CALCPOS1  SUB   DELTAS
433D  AE68   A8 6 68 A   1366           STA   POSITION
433E  4E87   48 6 87 A   1367           SUB   SDLO
                         1368 *                          CALCULATE PERCENT CHANGE FROM SDLO
433F  D2B7   D0 2 B7 A   1369           MPY   =100
4340  DE3F   D8 6 3F A   1370           DIV   REALSDLO
4341  A804   A8 0 04 A   1371           STA   E
4342  4C2E   48 4 2E A   1372           SUB   LIMIT
4343  B204   B0 2 04 A   1373           PJP   LIMREFUP
4344  2804   28 0 04 A   1374           LDA   E
4345  442E   40 4 2E A   1375           ADD   LIMIT
4346  BA11   B8 2 11 A   1376           NJP   LIMREFDN
4347  7214   70 2 14 A   1377           JMP   POSIT
4348  2C2E   28 4 2E A   1378 LIMREFUP  LDA   LIMIT
4349  42AD   40 2 AD A   1379           ADD   =100
434A  D63F   D0 6 3F A   1380 CAL       MPY   REALSDLO
434B  DAAB   D8 2 AB A   1381           DIV   =100
434C  B202   B0 2 02 A   1382           PJP   $+3
434D  50A0   50 0 A0 A   1383           EOR   K:XFFFF
434E  6005   60 0 05 A   1384           INC   A
434F  A803   A8 0 03 A   1385           STA   G
---------------------------------------------------------------
4350  2EA0   28 6 A0 A   1386           LDA   FXOOFF
4351  D44D   D0 4 4D A   1387           MPY   UNITSPMM
4352  DAA4   D8 2 A4 A   1388           DIV   =100
4353  A804   A8 0 04 A   1389           STA   E
4354  2803   28 0 03 A   1390           LDA   G
4355  4804   48 0 04 A   1391           SUB   E
4356  AE68   A8 6 68 A   1392           STA   POSITION
4357  7204   70 2 04 A   1393           JMP   POSIT
4358  2A9E   28 2 9E A   1394 LIMREFDN  LDA   =100
4359  4C2E   48 4 2E A   1395           SUB   LIMIT
435A  72EF   70 2 EF A   1396           JMP   CAL
435B  435B   40 3 5B A   1397           LPL
                         1398 *                          OUTPUT MILL RPM REF PROPORTIONAL
                         1399 *                          TO SCREW DOWN MOVEMENT
      435C   40 3 5C A   1400 POSIT     EQU   $
                         1401 *                          IS MOVEMENT UP OR DOWN
435C  2E64   28 6 64 A   1402           LDA   OLDREF
435D  F214   F0 2 14 A   1403           ZJP   LIGHTON
435E  4E68   48 6 68 A   1404           SUB   POSITION
                         1405           SKP,DIGLOOP+1    DIGITAL,ANALOG
                         1407
                         1408
                         1410
      435F   40 3 5F A   1447 ANALOG    EQU   $
                         1448
                         1449
                         1450 *                          SECTION FOR ANALOG LOOPERS
                         1451
435F  18AB   18 0 AB A   1452           LDG   K:X6
4360  D645   D0 6 45 A   1453           MPY   LOOPGAIN
4361  DA95   D8 2 95 A   1454           DIV   =100
4362  442F   40 4 2F A   1455           ADD   LOOPSET
4363  B202   B0 2 02 A   1456           PJP   $+3
4364  3805   38 0 05 A   1457           STZ   A
4365  7205   70 2 05 A   1458           JMP   LOOPSTRT
4366  48A2   48 0 A2 A   1459           SUB   K:XFF
4367  B202   B0 2 02 A   1460           PJP   $+3
4368  40A2   40 0 A2 A   1461           ADD   K:XFF
---------------------------------------------------------------
4369  7201   70 2 01 A   1462           JMP   LOOPSTRT
436A  28A2   28 0 A2 A   1463           LDA   K:XFF
      436B   40 3 6B A   1464 LOOPSTRT  EQU   $
436B  9805   98 0 05 A   1465           SHF   A
436C  4643   40 6 43 A   1466           ADD   CARDPT
436D  2001   20 0 01 A   1467           LDE   B
436E  A482   A0 4 82 A   1468           STE   SAVEB
436F  0E44   08 6 44 A   1469           LDB   LOOPCHNO
                         1470 *                          FOR THE IOA INSTRUCTION, 'A' WILL
                         1471 *                          CONTAIN THE PATTERN JUST CALC. IN
                         1472 *                          BITS 6 - 13, THE CARD NO. IN BITS
                         1473 *                          2 - 5, AND THE CARD POINT IN BITS
                         1474 *                          0 - 1.
4370  8C00   88 4 00 A   1475           IOA   0,B
      0000   00 0 00 A   1476           BSB
4371  0B18   08 3 18 A   1477           LDB   SAVEB
      410F   40 1 0F A   1478           BSB   D
      4372   40 3 72 A   1479 LIGHTON   EQU   $
                         1480 *                          TURN ON AGC IN MOTION LIGHT
4372  ED29   E8 5 29 A   1481           SST   *S:CCO,B
4373  0001   00 0 01 A   1482           DAT   AGCNUM-D
4374  0002   00 0 02 A   1483           DAT   AGCPAT-D
4375  0003   00 0 03 A   1484           DAT   AGCREG-D
4376  0059   00 0 59 A   1485           DAT   AGCMASK-D
                         1486 *                          BID POSITIONING PACKAGE
4377  2E68   28 6 68 A   1487           LDA   POSITION
4378  AC3E   A8 4 3E A   1488           STA   POSITN
4379  2C63   28 4 63 A   1489           LDA   DRNO
437A  420E   40 2 0E A   1490           ADD   =X'8000'
437B  AC86   A8 4 86 A   1491           STA   TEMPDRNO
437C  ED3B   E8 5 3B A   1492           SST   *STRTPOS,B
437D  0086   00 0 86 A   1493           DAT   TEMPDRNO-D
437E  003E   00 0 3E A   1494           DAT   POSITN-D
                         1495 *                          UPDATE OLD REFERENCE
437F  2E68   28 6 68 A   1496           LDA   POSITION
```

AUTOMATIC GAUGE CONTROL

```
 4380  AE64   A8 6 64 A   1497            STA    OLDREF
                          1498  *                        IS THIS FIRST SCAN ON TAIL END
                          1499  *                        IS STRIP OUT OF THE STAND BEHIND
 4381  2848   28 0 48 A   1500            LDA    DTAFLES
 4382  4C63   48 4 63 A   1501            SUB    DRNO
 4383  6005   60 0 05 A   1502            INC    A
 4384  1105   10 1 05 A   1503            LDC    *A
 4385  2E27   28 6 27 A   1504            LDA    SIS
 4386  BCBE   B8 4 BE A   1505            NJP    END
 4387  7203   70 2 03 A   1506            JMP    TESTAIL
 4388  8000   80 0 00 A   1507            LPL
 4389  4191   40 1 91 A
 438A  438A   40 3 8A A
                          1508  *                        STRIP IS OUT OF STAND BEHIND THIS
                          1509  *                        RESTORE C REGISTER
       438B   40 3 8B A   1510  TESTAIL   EQU    $
 438B  1483   10 4 83 A   1511            LDC    SAVEC
 438C  2E59   28 6 59 A   1512            LDA    FRSTTAIL
 438D  BCBE   B8 4 BE A   1513            NJP    END
                          1514  *                        IS STAND ON PRESET
 438E  6E59   68 6 59 A   1515            DCR    FRSTTAIL
 438F  2E23   28 6 23 A   1516            LDA    MCI
 4390  6005   60 0 05 A   1517            INC    A
 4391  2905   28 1 05 A   1518            LDA    *A
 4392  5C08   58 4 08 A   1519            AND    BITPAT3
 4393  F4BE   F0 4 BE A   1520            ZJP    END
                          1521  *                        YES, IS TAIL END COMPENSATION SELECT
 4394  2D04   28 5 04 A   1522            LDA    *AGCMREG
 4395  5C09   58 4 09 A   1523            AND    BITPAT4
 4396  F4BE   F0 4 BE A   1524            ZJP    END
                          1525  *                        IS THIS LAST STANS
 4397  2C63   28 4 63 A   1526            LDA    DRNO
 4398  4C3C   48 4 3C A   1527            SUB    NOOFDRVS
 4399  F4BE   F0 4 BE A   1528            ZJP    END
                          1529  *                        NO, COMPENSATE NEXT STZND
 439A  2848   28 0 48 A   1530            LDA    DTAFLES
 439B  4C63   48 4 63 A   1531            SUB    DRNO
 439C  6805   68 0 05 A   1532            DCR    A
 439D  1105   10 1 05 A   1533            LDC    *A
 439E  3E97   38 6 97 A   1534            STZ    TAILCOMP
 439F  6E97   68 6 97 A   1535            DCR    TAILCOMP
 43A0  1483   10 4 83 A   1536            LDC    SAVEC
                          1537  *                        SET UP COMPENSATION TIMI G
 43A1  2E8A   28 6 8A A   1538            LDA    SEPARATE
 43A2  D23E   D0 2 3E A   1539            MPY    =600
 43A3  DE4E   D8 6 4E A   1540            DIV    CIRCUM
 43A4  3804   38 0 04 A   1541            STZ    E
 43A5  DE8D   D8 6 8D A   1542            DIV    SPEED
 43A6  A804   A8 0 04 A   1543            STA    E
 43A7  2848   28 0 48 A   1544            LDA    DTAFLES
 43A8  4C63   48 4 63 A   1545            SUB    DRNO
 43A9  6805   68 0 05 A   1546            DCR    A
 43AA  1105   10 1 05 A   1547            LDC    *A
 43AB  2804   28 0 04 A   1548            LDA    E
 43AC  AE98   A8 6 98 A   1549            STA    TAILTIME
                          1550  *                        TAILTIME IS ZEROED WHEN STRIP
                          1551  *                        REACHES NEXT STAND
 43AD  2849   28 0 49 A   1552            LDA    TMDLYTBL
 43AE  4233   40 2 33 A   1553            ADD    =X'2D'
 43AF  4463   40 4 63 A   1554            ADD    DRNO
 43B0  A804   A8 0 04 A   1555            STA    E
 43B1  2E98   28 6 98 A   1556            LDA    TAILTIME
 43B2  A904   A8 1 04 A   1557            STA    *E
 43B3  3E98   38 6 98 A   1558            STZ    TAILTIME
 43B4  6E98   68 6 98 A   1559            DCR    TAILTIME
                          1560  *                        IF ONE OF LAST 4 STANDS, PROCESS
                          1561  *                        TWO STANDS
 43B5  2C63   28 4 63 A   1562            LDA    DRNO
 43B6  4882   48 0 B2 A   1563            SUB    K:X4
 43B7  BCBE   B8 4 BE A   1564            NJP    END
                          1565  *                        IS THIS SECOND LAST STAND
 43B8  2C3C   28 4 3C A   1566            LDA    NOOFDRVS
 43B9  6805   68 0 05 A   1567            DCR    A
 43BA  4C63   48 4 63 A   1568            SUB    DRNO
 43BB  F4BE   F0 4 BE A   1569            ZJP    END
                          1570  *                        NO, COMPENSATE NEXT TWO STANDS
 43BC  2848   28 0 48 A   1571            LDA    DTAFLES
 43BD  4C63   48 4 63 A   1572            SUB    DRNO
 43BE  6805   68 0 05 A   1573            DCR    A
 43BF  6805   68 0 05 A   1574            DCR    A
 43C0  1105   10 1 05 A   1575            LDC    *A
 43C1  3E97   38 6 97 A   1576            STZ    TAILCOMP
 43C2  6E97   68 6 97 A   1577            DCR    TAILCOMP
 43C3  6E97   68 6 97 A   1578            DCR    TAILCOMP
                          1579  *                        SET UP COMPENSATION TIMING
 43C4  2848   28 0 48 A   1580            LDA    DTAFLES
 43C5  4C63   48 4 63 A   1581            SUB    DRNO
 43C6  6805   68 0 05 A   1582            DCR    A
 43C7  1105   10 1 05 A   1583            LDC    *A
 43C8  2E8A   28 6 8A A   1584            LDA    SEPARATE
 43C9  D217   D0 2 17 A   1585            MPY    =600
 43CA  DE4E   D8 6 4E A   1586            DIV    CIRCUM
 43CB  3804   38 0 04 A   1587            STZ    E
 43CC  DE8D   D8 6 8D A   1588            DIV    SPEED
 43CD  A804   A8 0 04 A   1589            STA    E
 43CE  2848   28 0 48 A   1590            LDA    DTAFLES
 43CF  4C63   48 4 63 A   1591            SUB    DRNO
 43D0  6805   68 0 05 A   1592            DCR    A
 43D1  6805   68 0 05 A   1593            DCR    A
 43D2  1105   10 1 05 A   1594            LDC    *A
 43D3  A698   A0 6 98 A   1595            STE    TAILTIME
 43D4  1105   10 1 05 A   1596            LDC    *A
```

AUTOMATIC GAUGE CONTROL

```
43D5  A698   A0 6 98 A                STE       TAILTIME
43D6  2849   28 0 49 A                LDA       TMDLYTBL
43D7  420A   40 2 0A A                ADD       =X'2D'
43D8  4463   40 4 63 A                ADD       DRNO
43D9  6005   60 0 05 A                INC       A
43DA  A804   A8 0 04 A                STA       E
43DB  2E98   28 6 98 A                LDA       TAILTIME
43DC  A904   A8 1 04 A                STA       *E
43DD  3E98   38 6 98 A                STZ       TAILTIME
43DE  6E98   68 6 98 A                DCR       TAILTIME
43DF  74BE   70 4 BE A                JMP       END
43E0  0258   00 2 58 A                LPL
43E1  0C2D   00 0 2D A
                                      EJE
                            *
```

AGC XRAY MONITOR

```
                                      TTL       'AGC XRAY MONITOR'
                            *
                            *                                     THIS PROGRAM RUNS ON THE AGC TASK LEV
                            *                                     IT USES THE READINGS FROM THE
                            *                                     XRAY TO KEEP THE ROLL FORCE AGC ON
                            *                                     ON ABSOLUTE GAUGE.
                            *
        43E2   40 3 E2 A    XRAYPR    EQU       $
                            *                                     IS MONITOR ON
43E2  2D58   28 5 58 A                LDA       *XRONREG
43E3  5C3D   58 4 3D A                AND       ONBITPAT
43E4  F213   F0 2 13 A                ZJP       MONOFF
                            *                                     HAS TRANSPORT TIME DELAY EXPIRED
43E5  2C72   28 4 72 A                LDA       MONITIME
43E6  F201   F0 2 01 A                ZJP       GAUGON
43E7  74BE   70 4 BE A                JMP       END
        43E8   40 3 E8 A    GAUGON    EQU       $
43E8  2891   28 0 91 A                LDA       XRAYNO
43E9  4881   48 0 81 A                SUB       K:X2
43EA  F213   F0 2 13 A                ZJP       CHK2


43EB  2D51   28 5 51 A                LDA       *XRAY1REG
43EC  5C54   58 4 54 A                AND       XSELBIT1
                            *                                     IS XRAY 1 SELECTED
                            *                                      NO: ZJP  END
43ED  F4BE   F0 4 BE A                ZJP       END
43EE  2D56   28 5 56 A                LDA       *XSELREG1
43EF  5C18   58 4 18 A                AND       GAGEBIT1
                            *                                     IS XRAY 1 MEASURING
                            *                                     NO:  ZJP   NOXRAY
43F0  F203   F0 2 03 A                ZJP       NOXRAY
43F1  2C4A   28 4 4A A                LDA       THREG1
43F2  AC89   A8 4 89 A                STA       THICKREG
43F3  7213   70 2 13 A                JMP       CONVXRAY


        43F4   40 3 F4 A    NOXRAY    EQU       $
                            *                                     CLEAR HEAD END FLAGS
43F4  3C72   38 4 72 A                STZ       MONITIME
43F5  2C53   28 4 53 A                LDA       XRHDTIME
43F6  AC66   A8 4 66 A                STA       FRSTX
43F7  3C84   38 4 84 A                STZ       SCNDX
        43F8   40 3 F8 A    MONOFF    EQU       $
                            *                                     TURN OFF 'MONITOR' LIGHT BY
                            *                                     OUTPUTTING A ZERO
43F8  ED29   E8 5 29 A                SST       *S:CC0,B
43F9  003A   00 0 3A A                DAT       MONONUM-D
43FA  0C34   00 0 34 A                DAT       MONOFPAT-D
43FB  003B   00 0 3B A                DAT       MONONREG-D
43FC  0038   00 0 38 A                DAT       MONONMSK-D
43FD  74BE   70 4 BE A                JMP       END


        43FE   40 3 FE A    CHK2      EQU       $
43FE  2D52   28 5 52 A                LDA       *XRAY2REG
43FF  5C55   58 4 55 A                AND       XSELBIT2
                            *                                     IS XRAY 2 SELECTED
                            *                                      NO: ZJP  END
4400  F4BE   F0 4 BE A                ZJP       END
4401  2D57   28 5 57 A                LDA       *XSELREG2
4402  5C1C   58 4 1C A                AND       GAGEBIT2
                            *                                     IS XRAY 2 MEASURING
                            *                                     NO:  ZJP   NOXRAY
4403  F2F0   F0 2 F0 A                ZJP       NOXRAY
4404  2C4B   28 4 4B A                LDA       THREG2
4405  AC89   A8 4 89 A                STA       THICKREG
4406  7200   70 2 00 A                JMP       CONVXRAY
                            *                                     CONVERT XRAY DEVIATION
                            *                                     TO ENCODER UNITS
        4407   40 4 07 A    CONVXRAY  EQU       $
4407  2C66   28 4 66 A                LDA       FRSTX
4408  BA01   B8 2 01 A                NJP       $+2
4409  3C67   38 4 67 A                STZ       GAGEREAP
440A  2890   28 0 90 A                LDA       XRAY
440B  D440   D0 4 40 A                MPY       UNITSPMM
440C  DA1E   D8 2 1E A                DIV       =100
440D  4C67   48 4 67 A                SUB       GAGEREAP
                            *                                     GAUGE DEV IN ENCODER UNITS
440E  AC69   A8 4 69 A                STA       GAUGEDEV
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AGC XRAY MONITOR

```
                                    *                                CALCULATE PERCENT DEVIATION
        440F    40 4 0F A    READGAUG EQU    $
                                    *                                     READ NOMINAL GAUGE
440F    2489    20 4 89 A             LDE    THICKREG
                                    *                                LDA WITH NO. OF BCD DIGITS
4410    28B2    28 0 B2 A             LDA    K:X4
4411    ED2E    E8 5 2E A             SST    *TWHEX,B
4412    D44D    D0 4 4D A             MPY    UNITSPMM
4413    DA17    D8 2 17 A             DIV    =100
4414    4467    40 4 67 A             ADD    GAGEREAP
                                    *                                NOM. XRAY GAUGE IN ENCODER UNITS
4415    AC77    A8 4 77 A             STA    NOMINAL
                                    *                                CONVERT DEVIATION TO PERCENT
4416    2C69    28 4 69 A             LDA    GAUGEDEV
4417    D213    D0 2 13 A             MPY    =100
4418    DC77    D8 4 77 A             DIV    NOMINAL
                                    *                                  GAUGE DEVIATION
4419    AC7D    A8 4 7D A             STA    PRCNTDEV

                                    *                                IF DEVIATION IS OUT OF LIMITS,
                                    *                                PRINT MESSAGE
441A    4C31    48 4 31 A             SUB    MAXGAGE
441B    B207    B0 2 07 A             PJP    MESSAG10
441C    2C36    28 4 36 A             LDA    MINGAGE
441D    4C7D    48 4 7D A             SUB    PRCNTDEV
441E    B204    B0 2 04 A             PJP    MESSAG10


        441F    40 4 1F A    CHKSCAN1 EQU    $
                                    *                                IS THIS FIRST SCAN ON BAR
                                    *                                YES,SET FIRST SCAN FLAG AND EXIT
441F    2C66    28 4 66 A             LDA    FRSTX
4420    BA0C    B8 2 0C A             NJP    CHKSCAN2
4421    6C66    68 4 66 A             DCR    FRSTX
4422    74BE    70 4 BE A             JMP    END


        4423    40 4 23 A    MESSAG10 EQU    $
                                    *                                MESSAGE LOG WILL PRINT MESSAGE 10
                                    *                                'GAUGE DEVIATION IS TOO LARGE'
4423    284C    28 0 4C A             LDA    MESSAGE
4424    4207    40 2 07 A             ADD    =10
4425    A804    A8 0 04 A             STA    E
4426    3805    38 0 05 A             STZ    A
4427    6805    68 0 05 A             DCR    A
4428    A904    A8 1 04 A             STA    *E
4429    74BE    70 4 BE A             JMP    END
442A    0064    00 0 64 A             LPL
442B    000A    00 0 0A A
442C    442C    40 4 2C A
        442D    40 4 2D A    CHKSCAN2 EQU    $
442D    2C84    28 4 84 A             LDA    SCNDX
                                    *                                IS THIS HEADEND OF BAR
                                    *                                NO: NJP MAINMONI
442E    BB1B    B8 3 1B A             NJP    MAINMONI
                                    *                                SET SECOND SCAN FLAG
442F    3C84    38 4 84 A             STZ    SCNDX
4430    6C84    68 4 84 A             DCR    SCNDX
                                    *                                INITIALIZE AVERAGING FLAGS
4431    3C8A    38 4 8A A             STZ    WF
4432    648A    60 4 8A A             INC    WF
4433    3C5B    38 4 5B A             STZ    AVERAGER
                                      EJE
                                    *                                ADAPTIVE ROUTINE
                                    *                                PROCESS HEAD END

                                    *                                ENTERED ONLY ON 'SECOND SCAN'
                                    *
                                    *                                THIS ROUTINE CALCULATES P AND
                                    *                                STORES IT IN A LEARNING TABLE
                                    *                                IT ALSO CALCULATES THE STANDARD
                                    *                                DEVIATION OF EACH P IN THE TABLE
                                    *
                                    *                                IS AGC MASTER ON.
                                    *                                FIND THICKNESS OF PRODUCT
                                    *                                BY READING SCREW DOWN LOCK-ON
                                    *                                OF LAST STAND.
4434    2848    28 0 48 A             LDA    DTAFLES
4435    4C3C    48 4 3C A             SUB    NOOFDRVS
4436    1105    10 1 05 A             LDC    *A
4437    2C77    28 4 77 A             LDA    NOMINAL
4438    4469    40 4 69 A             ADD    GAUGEDEV
4439    AE9B    A8 6 9B A             STA    THICK
443A    AC6D    A8 4 6D A             STA    LASTSTND
                                    *                                CALCULATE METERS/MIN OF LAST STAND

                                    *                                READ ROLL DIAMETER
443B    2E4E    28 6 4E A             LDA    CIRCUM
                                    *                                MULTIPLY BY RPM
443C    D68D    D0 6 8D A             MPY    SPEED
                                    *                                CONVERT TO METERS
443D    DA0D    D8 2 0D A             DIV    =1000
                                    *                                ANSWER IS METERS PER MINUTE
443E    AC71    A8 4 71 A             STA    MPMLS
443F    3C63    38 4 63 A             STZ    DRNO




        4440    40 4 40 A    NEXTSTAN EQU    $
4440    6463    60 4 63 A             INC    DRNO
4441    2848    28 0 48 A             LDA    DTAFLES
4442    4C63    48 4 63 A             SUB    DRNO
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AGC XRAY MONITOR

```
4443  1105   10 1 05 A               LDC     *A
4444  2905   28 1 05 A               LDA     *A
4445  AC83   A8 4 83 A               STA     SAVEC
4446  2E2A   28 6 2A A               LDA     NOTCALIB
                         *                                  IS ROLL FORCE OR SPEED FAULTY
                         *                                  YES; NJP 'HEADENDR' TO AVOID MASS
                         *                                  FLOW CALCULATION
4447  BB04   B8 3 04 A               NJP     HEADENDR
4448  7204   70 2 04 A               JMP     CALCGAGE
4449  453F   40 5 3F A               LPL
444A  03E8   00 3 E8 A
444B  44DD   40 4 DD A
444C  444C   40 4 4C A
                         *                                  CALC GAGE OF PROD. LEAVING STAND

                         *                                  EXIT GAUGE=DELIVERY GAUGE*MPMLS/MPM


      444D   40 4 4D A   CALCGAGE EQU     $

                         *                                  CALCULATE METERS PER MINUTE OF THIS
                         *                                  STAND

444D  2E4E   28 6 4E A               LDA     CIRCUM
444E  D68D   D0 6 8D A               MPY     SPEED
444F  DAFB   D8 2 FB A               DIV     =1000
4450  AE63   A8 6 63 A               STA     MPM
                         *                                  CALCULATE THIS STAND'S DELIVERY
                         *                                  GAUGE
                         *                                  IN ENCODER UNITS

                         *                                  GAUGE=(MPMLS/MPM)(LSTHICK)
4451  2C6D   28 4 6D A               LDA     LASTSTND
4452  D471   D0 4 71 A               MPY     MPMLS
4453  DE63   D8 6 63 A               DIV     MPM
                         *                                  DELIVERY GAUGE IN ENCODER UNITS
4454  AE9B   A8 6 9B A               STA     THICK

                         *                                  PW CAN NOT BE CALCULATED FOR STAND 0
                         *                                  ONE
4455  2C63   28 4 63 A               LDA     DRNO
4456  6805   68 0 05 A               DCR     A
4457  F2E8   F0 2 E8 A               ZJP     NEXTSTAND
                         *                                  PW=(THICK(N-1)-THICK(N))(WIDTH)(HARD
                         *                                  /FORCE
                         *                                  CALCULATE CHANGE IN THICKNESS
4458  2848   28 0 48 A               LDA     DTAFLES
4459  4C63   48 4 63 A               SUB     DRNO
445A  6005   60 0 05 A               INC     A
445B  1105   10 1 05 A               LDC     *A
445C  2E9B   28 6 9B A               LDA     THICK
445D  1483   10 4 83 A               LDC     SAVEC
445E  4E9B   48 6 9B A               SUB     THICK
                         *                                  STAND DRAFT IN ENCODER UNITS
445F  AC87   A8 4 87 A               STA     TEMP


4460  2D1E   28 5 1E A               LDA     *HARDREG
4461  5C1D   58 4 1D A               AND     HARDBITS
4462  1A1E   18 2 1E A               LDG     *SRA+4
4463  9805   98 0 05 A               SHF     A
4464  AC6A   A8 4 6A A               STA     HARDNESS
4465  2A1C   28 2 1C A               LDA     *HARDTABL
4466  446A   40 4 6A A               ADD     HARDNESS
4467  2905   28 1 05 A               LDA     *A
4468  AC6A   A8 4 6A A               STA     HARDNESS
4469  244F   20 4 4F A               LDE     WIDTHREG
446A  28B2   28 0 B2 A               LDA     K:X4
446B  ED2E   E8 5 2E A               SST     *TWHEX,B
                         *                                  CORRECT FOR HARDNESS
446C  D46A   D0 4 6A A               MPY     HARDNESS
                         *                                  CONVERT TO ENCODER UNITS PER KILTON
446D  DE56   D8 6 56 A               DIV     FORCELB
446E  D487   D0 4 87 A               MPY     TEMP
446F  DABC   D8 2 BC A               DIV     =10
4470  AC7F   A8 4 7F A               STA     PW+1
                         *                                  IS PW NEG., YES: NJP HEADENDR
4471  BA6C   B8 2 6C A               NJP     HEADENDR
                         *                                  STORE IN PW TABLE
                         *                                  DETERMINE GAUGE CLASS
4472  3C5F   38 4 5F A               STZ     COUNT
4473  2E42   28 6 42 A   LARGRC      LDA     CLASS1
4474  445F   40 4 5F A               ADD     COUNT
4475  2905   28 1 05 A               LDA     *A
4476  4E87   48 6 87 A               SUB     SDLO
4477  B20B   B0 2 0B A               PJP     THSCLASS
4478  645F   60 4 5F A               INC     COUNT
4479  2C5F   28 4 5F A               LDA     COUNT
447A  48AE   48 0 AE A               SUB     K:X7
447B  B201   B0 2 01 A               PJP     $+2
447C  72F6   70 2 F6 A               JMP     LARGRC
447D  28AE   28 0 AE A               LDA     K:X7
447E  AC5F   A8 4 5F A               STA     COUNT
447F  7203   70 2 03 A               JMP     THSCLASS
4480  4004   40 0 04 A               LPL
4481  412E   40 1 2E A
4482  4482   40 4 82 A
                         *                                  AVERAGE PW INTO TABLE
      4483   40 4 83 A   THSCLASS EQU     $
4483  2E73   28 6 73 A               LDA     PWTABLE
4484  445F   40 4 5F A               ADD     COUNT
4485  2905   28 1 05 A               LDA     *A
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AGC XRAY MØNITØR

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4486  AC78   A8 4 78 A             STA    ØLDMEAN
                         *                              PW=(ØLDMEAN*ØLDSIZE+NEWPW)/ØLDS+1
4487  2E7E   28 6 7E A             LDA    SAMPLSIZ
4488  445F   40 4 5F A             ADD    CØUNT
4489  A804   A8 0 04 A             STA    E
448A  2905   28 1 05 A             LDA    *A
448B  AC7B   A8 4 7B A             STA    ØLDSIZE
448C  4A4D   48 2 4D A             SUB    =32
448D  6201   60 2 01 A             PJP    $+2                  LIMIT SAMPLSIZ TØ 32
448E  6104   60 1 04 A             INC    *E
448F  2C78   28 4 78 A             LDA    ØLDMEAN
4490  D47B   D0 4 7B A             MPY    ØLDSIZE
4491  C47E   C0 4 7E A             ADA    PW
4492  1C7B   18 4 7B A             LDG    ØLDSIZE
4493  6003   60 0 03 A             INC    G
4494  D803   D8 0 03 A             DIV    G
4495  AC73   A8 4 73 A             STA    NEWMEAN
4496  2E73   28 6 73 A             LDA    PWTABLE
4497  445F   40 4 5F A             ADD    CØUNT
4498  A804   A8 0 04 A             STA    E
4499  2C73   28 4 73 A             LDA    NEWMEAN
449A  A904   A8 1 04 A             STA    *E
449B  2C7B   28 4 7B A             LDA    ØLDSIZE
449C  6005   60 0 05 A             INC    A
449D  AC76   A8 4 76 A             STA    NEWSIZE
                         *                              SQUARE NEW MEAN AND SAVE
449E  2C73   28 4 73 A             LDA    NEWMEAN
449F  D005   D0 0 05 A             MPY    A
44A0  A48C   A0 4 8C A             STE    XTEMP
44A1  AC8D   A8 4 8D A             STA    XTEMP+1
44A2  2804   28 0 04 A             LDA    E
44A3  D476   D0 4 76 A             MPY    NEWSIZE
44A4  AC74   A8 4 74 A             STA    NEWMEAN2
44A5  3C75   38 4 75 A             STZ    NEWMEAN2+1
44A6  3804   38 0 04 A             STZ    E
44A7  1A33   18 2 33 A             LDG    =DRA+1
44A8  2C8C   28 4 8C A             LDA    XTEMP
44A9  9804   98 0 04 A             SHF    E
44AA  D476   D0 4 76 A             MPY    NEWSIZE
44AB  1A30   18 2 30 A             LDG    =DLA+1
44AC  9804   98 0 04 A             SHF    E
44AD  C474   C0 4 74 A             ADA    NEWMEAN2
44AE  A474   A0 4 74 A             STE    NEWMEAN2
44AF  AC75   A8 4 75 A             STA    NEWMEAN2+1
                         *                              SQUARE ØLD MEAN, ADD ØLD VARIENCE
                         *                                WHICH IS (DEV/8)**2
44B0  2E8E   28 6 8E A             LDA    STANDEV
44B1  445F   40 4 5F A             ADD    CØUNT
44B2  2905   28 1 05 A             LDA    *A
44B3  D0B4   D0 0 B4 A             MPY    K:X10
44B4  AC88   A8 4 88 A             STA    TEMP+1
44B5  A487   A0 4 87 A             STE    TEMP

44B6  2C78   28 4 78 A             LDA    ØLDMEAN
44B7  D005   D0 0 05 A             MPY    A
44B8  C487   C0 4 87 A             ADA    TEMP
44B9  A48C   A0 4 8C A             STE    XTEMP
44BA  AC8D   A8 4 8D A             STA    XTEMP+1

44BB  2804   28 0 04 A             LDA    E
                         *                              MULTIPLY BY ØLDSIZE
44BC  D47B   D0 4 7B A             MPY    ØLDSIZE
44BD  AC79   A8 4 79 A             STA    ØLDMEAN2
44BE  3C7A   38 4 7A A             STZ    ØLDMEAN2+1
44BF  3804   38 0 04 A             STZ    E
44C0  1A1A   18 2 1A A             LDG    =DRA+1
44C1  2C8C   28 4 8C A             LDA    XTEMP
44C2  9804   98 0 04 A             SHF    E
44C3  D47B   D0 4 7B A             MPY    ØLDSIZE
44C4  1A17   18 2 17 A             LDG    =DLA+1
44C5  9804   98 0 04 A             SHF    E
44C6  C479   C0 4 79 A             ADA    ØLDMEAN2
                         *                              UPDATED 'ØLD MEAN SQUARED'
44C7  A479   A0 4 79 A             STE    ØLDMEAN2
44C8  AC7A   A8 4 7A A             STA    ØLDMEAN2+1

44C9  2C76   28 4 76 A             LDA    NEWSIZE
44CA  D0B4   D0 0 B4 A             MPY    K:X10
44CB  A803   A8 0 03 A             STA    G
                         *                              SQUARE PW
44CC  2C7F   28 4 7F A             LDA    PW+1
44CD  D005   D0 0 05 A             MPY    A
                         *                              ADD ØLD MEAN SQUARED
44CE  C479   C0 4 79 A             ADA    ØLDMEAN2
44CF  CC74   C8 4 74 A             SDA    NEWMEAN2
44D0  D803   D8 0 03 A             DIV    G
44D1  A804   A8 0 04 A             STA    E
                         *                              STØRE ANSWER IN TABLE ØF STANDARD DE
44D2  2E8E   28 6 8E A             LDA    STANDEV
44D3  445F   40 4 5F A             ADD    CØUNT
44D4  A105   A0 1 05 A             STE    *A
44D5  2C63   28 4 63 A             LDA    DRNØ
44D6  4C3C   48 4 3C A             SUB    NØØFDRVS
44D7  8206   80 2 06 A             PJP    HEADENDR
44D8  7305   70 3 05 A             JMP    NEXTSTAND
44D9  0020   00 0 20 A             LPL
44DA  C001   C0 0 01 A
44DB  8001   80 0 01 A
44DC  44DD   40 4 DD A
44DD  443F   40 4 3F A
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          44DE   40 4 DE A            EJE
                               *              THIS ROUTINE IMPROVES ON THE
                               *              INITIAL SET-UP OF THE SCREWS
                               *              BY EVALUATING THE GAUGE OF THE
                               *              HEAD END OF A STRIP AND THEN
                               *              ADJUSTING THE TABLE OF PRESET
                               *              VALUES,
                               HEADENDR EQU   $
44DE      2C69   28 4 69 A              LDA   GAUGEDEV
44DF      D226   D0 2 26 A              MPY   *100
44E0      DC4D   D8 4 4D A              DIV   UNITSPMM
                               *              STORE HEAD END GAGE
44E1      A864   A8 0 64 A              STA   HEADGAGE

44E2      2848   28 0 48 A              LDA   DTAFLES
44E3      4C3C   48 4 3C A              SUB   NOOFDRVS
44E4      1105   10 1 05 A              LDC   *A
44E5      6468   60 4 68 A              INC   HEADWF
                               *              INCREMENT HEAD END IMPORTANCE FACTOR
44E6      28AD   28 0 AD A              LDA   K:X5
44E7      AC85   A8 4 85 A              STA   STANDWF
44E8      2C3C   28 4 3C A              LDA   NOOFDRVS
44E9      6805   68 0 05 A              DCR   A
44EA      AC63   A8 4 63 A              STA   DRNO
                               *              READ PREVIOUS VALUE OF RESET TABLE
                               *              AND ADD CORRECTION
                               *              CORRECTION=(DEV*MPMLS/MPM)/HEADWF
                               *              *STANDWF/3
44EB      2E63   28 6 63 A              LDA   MPM
44EC      AC71   A8 4 71 A              STA   MPMLS


                               *              START WITH SECOND LAST STAND
          44ED   40 4 ED A     NXTSTND  EQU   $
44ED      2848   28 0 48 A              LDA   DTAFLES
44EE      4C63   48 4 63 A              SUB   DRNO
44EF      1105   10 1 05 A              LDC   *A
44F0      2E23   28 6 23 A              LDA   MCI
44F1      6C05   60 0 05 A              INC   A
44F2      2905   28 1 05 A              LDA   *A
44F3      5C49   58 4 49 A              AND   STDMONBT
                               *              IS THIS STAND'S MONITOR SELECTED
                               *              YES; JMP CORRECAL
44F4      F201   F0 2 01 A              ZJP   $+2
44F5      7203   70 2 03 A              JMP   CORRECAL
          44F6   40 4 F6 A     NEWDR    EQU   $
44F6      6C63   68 4 63 A              DCR   DRNO
                               *              GO TO 'LOCKSN' IF ALL STANDS CHK'D
44F7      F20F   F0 2 0F A              ZJP   LOCKON
44F8      72F4   70 2 F4 A              JMP   NXTSTND


          44F9   40 4 F9 A     CORRECAL EQU   $
44F9      2C71   28 4 71 A              LDA   MPMLS
44FA      D469   D0 4 69 A              MPY   GAUGEDEV
44FB      DE63   D8 6 63 A              DIV   MPM
44FC      D485   D0 4 85 A              MPY   STANDWF
44FD      DC66   D8 4 66 A              DIV   HEADWF
44FE      DCA0   D0 0 A0 A              MPY   K:XFFFF
44FF      D8AD   D8 0 AD A              DIV   K:X5
4500      4626   40 6 26 A              ADD   RESET
4501      AE26   A8 6 26 A              STA   RESET
4502      6C85   68 4 85 A              DCR   STANDWF
                               *              GO TO 'LOCKON' IF ALL STANDS CHK'D
4503      F203   F0 2 03 A              ZJP   LOCKON
4504      72F1   70 2 F1 A              JMP   NEWDR
4505      0064   00 0 64 A              LPL
4506      4506   40 5 06 A
                                        EJE
                               *              MONITOR WILL LOCK ON GAUGE IF
                               *              HOLD' IS SELECTED
                               *              GAUGE DEV. IS > 10% OR IF 'MON.

          4507   40 5 07 A     LOCKON   EQU   $
4507      2D35   28 5 35 A              LDA   *MHOLDREG
                               *              IS MONITOR HOLD SELECTED
4508      5C41   58 4 41 A              AND   GAGEPAT
4509      F201   F0 2 01 A              ZJP   $+2
                               *              YES; JMP HOLDON
450A      721B   70 2 1B A              JMP   HOLDON
                               *              IS DEVIATION OUT OF LIMIT
450B      2C69   28 4 69 A              LDA   GAUGEDEV
450C      4C30   48 4 30 A              SUB   MAXALLOW
450D      B204   B0 2 04 A              PJP   HOLD
450E      2C69   28 4 69 A              LDA   GAUGEDEV
450F      4430   40 4 30 A              ADD   MAXALLOW
4510      BA01   B8 2 01 A              NJP   HOLD
                               *              NO; JMP MAINMONI
4511      722E   70 2 2E A              JMP   MAINMONI
                               *              DETERMINE IF THIS IS TO BE ROLLED
                               *                LIGHT OR HEAVY
4512      2C77   28 4 77 A     HOLD     LDA   NOMINAL
4513      4469   40 4 69 A              ADD   GAUGEDEV
4514      A804   A8 0 04 A              STA   E
4515      3803   38 0 03 A              STZ   G
4516      2C69   28 4 69 A              LDA   GAUGEDEV
4517      B213   B0 2 13 A              PJP   HOLDTHIK
4518      28B4   28 0 B4 A              LDA   K:X10
4519      A803   A8 0 03 A              STA   G
                               *              PICK LIGHTER GAUGE AS NEW TARGET
                               *                BY SEARCHING 'GAGETBL'
451A      6803   68 0 03 A     HOLDTHIN DCR   G
451B      2803   28 0 03 A              LDA   G
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451C  F223  F0 2 23 A              ZJP   MAINMØNI
                        *                             ENTRY 1 ØF 'GAGETBL' IS SMALLEST
451D  2A5E  28 2 5E A              LDA   GAGETBL
451E  4003  40 0 03 A              ADD   G
451F  2905  28 1 05 A              LDA   *A
4520  AC67  A8 4 67 A              STA   GAGEREAP
4521  2804  28 0 04 A              LDA   E
4522  4C67  48 4 67 A              SUB   GAGEREAP
4523  4430  40 4 30 A              ADD   MAXALLØW
4524  BAF5  B8 2 F5 A              NJP   HØLDTHIN
4525  7210  70 2 10 A              JMP   PCTCALC
      4526  40 5 26 A   HØLDØN     EQU   $
                        *                             MØNITØR WILL HØLD PRESENT GAUGE
4526  2C69  28 4 69 A              LDA   GAUGEDEV
4527  AC67  A8 4 67 A              STA   GAGEREAP
4528  3C69  38 4 69 A              STZ   GAUGEDEV
4529  3805  38 0 05 A              STZ   A
452A  7214  70 2 14 A              JMP   PCTSTØRE
      452B  40 5 2B A   HØLDTHIK   EQU   $
                        *                             PICK HEAVIER GAUGE AS NEW TARGET
                        *                               BY SEARCHING 'GAGETBL'
                        *                             G IS LØØP CØUNTER
452B  6003  60 0 03 A              INC   G
452C  2803  28 0 03 A              LDA   G
452D  48B4  48 0 B4 A              SUB   K:X10
452E  B211  B0 2 11 A              PJP   MAINMØNI
452F  2A4C  28 2 4C A              LDA   GAGETBL          ADDRESS ØF 1 ENTRY ØF GAGETBL
                        *                             ENTRY 1 IS SMALLEST
4530  4003  40 0 03 A              ADD   G
4531  2905  28 1 05 A              LDA   *A
                        *                             DETERMINE NEW NØMINAL GAUGE
4532  AC67  A8 4 67 A              STA   GAGEREAP
4533  4804  48 0 04 A              SUB   E
4534  4430  40 4 30 A              ADD   MAXALLØW
4535  BAF5  B8 2 F5 A              NJP   HØLDTHIK
      4536  40 5 36 A   PCTCALC    EQU   $
                        *                             CALC PERCENT DEV FRØM LØCKØN
4536  1C67  18 4 67 A              LDG   GAGEREAP
                        *                             DETERMINE NEW DEVEIATIØN
4537  2C67  28 4 67 A              LDA   GAGEREAP
4538  4C77  48 4 77 A              SUB   NØMINAL
4539  AC67  A8 4 67 A              STA   GAGEREAP
453A  2C69  28 4 69 A              LDA   GAUGEDEV
453B  4C67  48 4 67 A              SUB   GAGEREAP
453C  AC69  A8 4 69 A              STA   GAUGEDEV
453D  D2C8  D0 2 C8 A              MPY   =100
453E  D803  D8 0 03 A              DIV   G
                        *                             PRCNTDEV IS % DEV. ØF LØCKØN
                        *                             FRØM NEW NØMINAL GAUGE
453F  AC7D  A8 4 7D A   PCTSTØRE   STA   PRCNTDEV
                                   EJE
      4540  40 5 40 A   MAINMØNI   EQU   $
                        *                             NØRMAL PATH:
                        *                             MAINTAIN ABSØLUTE CALIBRATIØN ØF RØL
                        *                             FØRCE SYSTEM
4540  2C3C  28 4 3C A              LDA   NØØFDRVS
4541  AC63  A8 4 63 A              STA   DRNØ
4542  2848  28 0 48 A              LDA   DTAFLES
4543  4C63  48 4 63 A              SUB   DRNØ
4544  1105  10 1 05 A              LDC   *A
4545  2E4E  28 6 4E A              LDA   CIRCUM
                        *                             CALCULATE LAST STAND SPEED
                        *                             IN METERS/MIN
4546  D68D  D0 6 8D A              MPY   SPEED
4547  DA6A  D8 2 6A A              DIV   =1000
4548  AC71  A8 4 71 A              STA   MPMLS
                        *                             EXIT THICK=XRAY THICK*MPMLS/MPM
4549  28AC  28 0 AC A              LDA   K:X3
454A  AC5E  A8 4 5E A              STA   CØMPF
      454B  40 5 4B A   SDLØØP     EQU   $
454B  2848  28 0 48 A              LDA   DTAFLES
454C  4C63  48 4 63 A              SUB   DRNØ
454D  6005  60 0 05 A              INC   A
454E  1105  10 1 05 A              LDC   *A
454F  2E11  28 6 11 A              LDA   CALFLAG
4550  B22F  B0 2 2F A              PJP   DECREM
                        *                             CHECK IF MØNITØR IS SELECTED ØN
                        *                             THIC STAND
4551  2E23  28 6 23 A              LDA   MCI
4552  6005  60 0 05 A              INC   A
4553  2905  28 1 05 A              LDA   *A
4554  5C49  58 4 49 A              AND   STDMØNBT
4555  F22A  F0 2 2A A              ZJP   DECREM
                        *                             CALCULATE RØLL FØRCE ERRØR
4556  2E4E  28 6 4E A              LDA   CIRCUM
4557  D68D  D0 6 8D A              MPY   SPEED
4558  DA59  D8 2 59 A              DIV   =1000
4559  AE63  A8 6 63 A              STA   MPM
                        *                             ØTHER=GAUGEDEV*MPMLS/MPM*J1/M2+
                        *                               ØTHER*J3/J4
455A  2C71  28 4 71 A              LDA   MPMLS
455B  D65C  D0 6 5C A              MPY   J1
455C  DE63  D8 6 63 A              DIV   MPM
455D  D469  D0 4 69 A              MPY   GAUGEDEV
455E  DC2A  D8 4 2A A              DIV   J2
455F  A803  A8 0 03 A              STA   G
4560  2E65  28 6 65 A              LDA   ØTHER
4561  D428  D0 4 28 A              MPY   J3
4562  DC2C  D8 4 2C A              DIV   J4
4563  4003  40 0 03 A              ADD   G
4564  A604  A8 0 04 A              STA   E
                        *                             E CØNTAINS ERRØR
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AGC XRAY MONITOR

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4565  BA1D  B8 2 1D A            NJP   NEGLIM
4566  4E3D  48 6 3D A            SUB   POSLIM
4567  BA01  B8 2 01 A            NJP   SCRPOS
4568  263D  20 6 3D A            LDE   POSLIM
4569  2804  28 0 04 A  SCRPOS    LDA   E
456A  AE65  A8 6 65 A            STA   OTHER
                       *                              IS ROLL FORCE TURNED OFF
456B  2E23  28 6 23 A            LDA   MCI
456C  6005  60 0 05 A            INC   A
456D  2905  28 1 05 A            LDA   *A
456E  5C07  58 4 07 A            AND   BITPAT2
456F  F201  F0 2 01 A            ZJP   $+2
4570  7208  70 2 08 A            JMP   OTHERCALC
                       *                              YES: OUTPUT CORRECTION OF XRAY
4571  E036  E8 5 36 A            SST   *GRAYBIN,B
4572  4E65  48 6 65 A            SUB   OTHER
4573  AC3E  A8 4 3E A            STA   POSITN
4574  2C63  28 4 63 A            LDA   DRNO
4575  423E  40 2 3E A            ADD   =X'8000'
4576  AC86  A8 4 86 A            STA   TEMPDRNO
4577  E03B  E8 5 3B A            SST   *STRTPOS,B
4578  0086  00 0 86 A            DAT   TEMPDRNO-D
4579  003E  00 0 3E A            DAT   POSITN-D
457A  7205  70 2 05 A            JMP   DECREM

457B  411A  40 1 1A A  GAGETBL   DAT   GAGETBLE+1

      457C  40 5 7C A  OTHERCAL  EQU   $
457C  6C5E  68 4 5E A            DCR   COMPF
457D  F201  F0 2 01 A            ZJP   $+2
457E  7201  70 2 01 A            JMP   DECREM
457F  3E65  38 6 65 A            STZ   OTHER
4580  6C63  68 4 63 A  DECREM    DCR   DRNO
4581  F205  F0 2 05 A            ZJP   ZEROGEFG
4582  72C8  70 2 C8 A            JMP   SDLOOP
4583  4E3C  48 6 3C A  NEGLIM    SUB   NEGLIMT
4584  B2E4  B0 2 E4 A            PJP   SCRPOS
4585  263C  20 6 3C A            LDE   NEGLIMT
4586  72E2  70 2 E2 A            JMP   SCRPOS
      4587  40 5 87 A  ZEROGEFG  EQU   $
                       *                              DETERMINE TIME DELAY TO FURTHEST
                       *                              STAND CORRECTED
4587  2C3C  28 4 3C A            LDA   NOOFDRVS
4588  AC63  A8 4 63 A            STA   DRNO
4589  2C4C  28 4 4C A            LDA   TIMEFUNC
458A  AC5E  A8 4 5E A            STA   COMPF
458B  AC72  A8 4 72 A            STA   MONITIME
      458C  40 5 8C A  TIMELOOP  EQU   $
458C  2848  28 0 48 A            LDA   DTAFLES
458D  4C63  48 4 63 A            SUB   DRNO
458E  1105  10 1 05 A            LDC   *A
                       *                              CHECK IF MONITOR IS SEELCTED
                       *                              FOR THIS STAND
458F  2E23  28 6 23 A            LDA   MCI
4590  6005  60 0 05 A            INC   A
4591  2905  28 1 05 A            LDA   *A
4592  5C49  58 4 49 A            AND   STDMONBT
4593  F201  F0 2 01 A            ZJP   $+2
4594  6C5E  68 4 5E A            DCR   COMPF
4595  3804  38 0 04 A            STZ   E
4596  2E8A  28 6 8A A            LDA   SEPARATE
4597  DE8D  D8 6 8D A            DIV   SPEED
4598  D21A  D0 2 1A A            MPY   =600
4599  DE4E  D8 6 4E A            DIV   CIRCUM
459A  A803  A8 0 03 A            STA   G
459B  2C72  28 4 72 A            LDA   MONITIME
459C  4003  40 0 03 A            ADD   G
459D  AC72  A8 4 72 A            STA   MONITIME
459E  2C5E  28 4 5E A            LDA   COMPF
459F  F203  F0 2 03 A            ZJP   SETTIMER
45A0  6C63  68 4 63 A  TIMEDEC   DCR   DRNO
45A1  F201  F0 2 01 A            ZJP   SETTIMER
45A2  72E9  70 2 E9 A            JMP   TIMELOOP
      45A3  40 5 A3 A  SETTIMER  EQU   $
45A3  2849  28 0 49 A            LDA   TMDLYTBL
45A4  443F  40 4 3F A            ADD   PROGRAMN
45A5  A804  A8 0 04 A            STA   E
45A6  2C72  28 4 72 A            LDA   MONITIME
45A7  A904  A8 1 04 A            STA   *E
      45A8  40 5 A8 A  LIGHT     EQU   $
                       *                              SET LIGHT MONITOR ON
45A8  E029  E8 5 29 A            SST   *SICCO,B
45A9  003A  00 0 3A A            DAT   MONONUM-D
45AA  0039  00 0 39 A            DAT   MONONPAT-D
45AB  0038  00 0 38 A            DAT   MONONREG-D
45AC  0038  00 0 38 A            DAT   MONONMSK-D
45AD  3C5A  38 4 5A A            STZ   AVERDEV
45AE  3C60  38 4 60 A            STZ   DEVWEIGF
45AF  6460  60 4 60 A            INC   DEVWEIGF
45B0  74BE  70 4 BE A            JMP   END
45B1  03E8  00 3 E8 A
45B2  0258  00 2 58 A
45B3  8000  80 0 00 A
      0000  00 0 00 A            END
0000  ERRORS
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We claim:

1. A gauge control system for a rolling mill having at least a first roll stand and a second roll stand operative with initial roll opening settings to reduce the gauge of a plurality of similar workpieces passed through said rolling mill, said system comprising:

means for measuring the gauge deviation of a first of said workpieces leaving said second roll stand,

means for determining a correction for adjusting the roll opening setting of at least said first roll stand for the passage of at least a second workpiece in accordance with a predetermined mass flow relationship between said gauge deviation of said first workpiece, the operating speed of said first roll stand and the operating speed of said second roll stand, and,

means for controlling the roll opening of said first roll stand for the passage of at least said second workpiece in accordance with said gauge correction.

2. The gauge control system for a rolling mill of claim 1, including

means for controlling the roll opening of said second roll stand in accordance with the measured roll force of that second roll stand and the predetermined mill spring characteristic of that second roll stand.

3. The gauge control system of claim 1, with said rolling mill having a plurality of roll stands and said second roll stand being the last roll stand of the rolling mill, said system including

means for controlling the roll opening of a third roll stand positioned between said first roll stand and said last roll stand during the passage of at least said second workpiece in accordance with said correction,

with said relationship including a weighting factor having a first value when said correction is determined for adjusting the roll opening of said first roll stand and having a second and different value when said correction is determined for adjusting the roll opening of said third roll stand.

4. The gauge control system for a rolling mill of claim 1, with said rolling mill having a plurality of roll stands operative to reduce the gauge of said plurality of workpieces passed through said rolling mill,

with said correction being determined by the relationship CORRECTION = (RPM_{LS}) GAUGE DEVIATION/(RPM_{TS}) WEIGHTING FACTOR, where the RPM_{TS} is the operating speed of said first roll stand, where RPM_{LS} is the operating speed of said second roll stand and the weighting factor is determined in relation to a desired portion of said determined correction that is to be applied to said first roll stand.

5. The gauge control system for a rolling mill of claim 1, with said second roll stand being controlled by a roll force gauge control system responsive to a roll force determined workpiece gauge leaving said second roll stand.

6. A method of controlling the workpiece gauge leaving a rolling mill having at least a first roll stand operative with initial roll opening settings to reduce the gauge of a plurality of similar workpieces passed through said rolling mill and including a device for measuring the gauge deviation of a first workpiece leaving said rolling mill, the steps of said method comprising:

determining a roll opening correction for application to said first roll stand during the passage of at least a second workpiece in accordance with a predetermined mass flow relationship with said gauge deviation of said first workpiece and the workpiece movement from said rolling mill as compared to the workpiece movement from said first roll stand, and

controlling the operation of said first roll stand in accordance with a roll opening setting modified by said correction.

7. The method of controlling the workpiece gauge leaving a rolling mill of claim 6, with said rolling mill having a plurality of roll stands operative to reduce the gauge of said plurality of workpieces passed through said rolling mill, with said method including:

determining the roll opening correction for application to each of selected roll stands during the passage of at least said second workpiece in accordance with said predetermined relationship and a predetermined weighting factor for each of said selected roll stands such that a decreasing portion of said correction is applied to each selected roll stand in relation to the distance of the selected roll stand ahead of the last roll stand of the rolling mill.

8. The method of controlling the workpiece gauge leaving a rolling mill of claim 6, with said rolling mill having a plurality of roll stands and with said plurality of workpieces being similar in at least one of gauge classification and grade classification, said method including:

determining a roll opening correction for application to each of selected roll stands during the passage of at least said second workpiece such that the roll opening setting of an earlier selected roll stand is corrected less than the roll opening setting of a later selected roll stand.

9. The method of controlling the workpiece gauge leaving a rolling mill of claim 6, with said rolling mill having a plurality of roll stands operative to reduce the gauge of said plurality of workpieces passed through said rolling mill, the steps of said method including:

determining a weighting factor in relation to each of selected roll stands for providing a predetermined portion of said roll opening correction to each selected roll stand, and

controlling the roll opening of each of said selected roll stands in accordance with said correction and said weighting factor for that roll stand.

10. The method of controlling the workpiece gauge leaving a rolling mill of claim 6 with said method including:

determining said roll opening correction in relation to a predetermined weighting factor for applying a decreased correction to said first roll stand in accordance with the distance between said first roll stand and the last roll stand of said rolling mill.

11. The gauge control system for a rolling mill of claim 1 with said correction being determined in accordance with a weighting factor in relation to a desired portion of said gauge correction that is to be applied to said first roll stand.

12. A gauge control system for a rolling mill having at least a first roll stand and a second roll stand operative to reduce the gauge of first and second workpieces passed through said rolling mill and including a device for measuring the gauge deviation of said first work-

piece leaving said second roll stand, said system comprising:

means for determining a gauge correction for application to said first roll stand during the passage of said second workpiece in accordance with a predetermined realtionship between said gauge deviation of said first workpiece, the operating speed of said first roll stand, the operating speed of said second roll stand and a weighting factor in relation to a desired portion of said determined gauge correction that is to be applied to said first roll stand, and

means for controlling the roll opening of said first roll stand during the passage of said second workpiece in accordance with said gauge correction.

13. A method of controlling the workpiece gauge leaving a rolling mill having at least a first roll stand operative to reduce the gauge of first and second workpieces passed through said rolling mill and in relation to a measured gauge deviation of said first workpiece leaving said rolling mill, the steps of said method comprising:

determining a gauge correction for application to said first roll stand during the passage of said second workpiece in accordance with a predetermined relationship between the measured gauge deviation of said first workpiece, the workpiece movement from said rolling mill as compared to the workpiece movement from said first roll stand,

determining a predetermined weighting factor in relation to said first roll stand, and

controlling the operation of said first roll stand in accordance with said gauge correction and said weighting factor.

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