04884

Distr.
LIMITED
ID/WG.146/98
25 July 1973
ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Third Interregional Symposium
on the Iron and Steel Industry
Brasilia, Brazil, 14 - 21 October 1973

Agenda item 7

AUTOMATION AND AUTOMATIC GAUGE CONTROL IN COLD ROLLING MILLS[1/]

by

Antonio Vicente Souza e Silva
Westinghouse Electric Company
Brazil

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.73-5264

04884

Distr. LIMITEE
ID/WG.146/98 RESUME
30 juillet 1973
FRANCAIS
Original : ANGLAIS

Organisation des Nations Unies pour le développement industriel

Troisième Colloque interrégional
sur la sidérurgie
Brasilia (Brésil), 14-21 octobre 1973
Point 7 de l'ordre du jour

RESUME

AUTOMATISATION DES LAMINOIRS A FROID ET CONTROLE AUTOMATIQUE DE L'EPAISSEUR DES TOLES[1]

par
Antonio Vicente Souza e Silva
Westinghouse Electric Company
(Brésil)

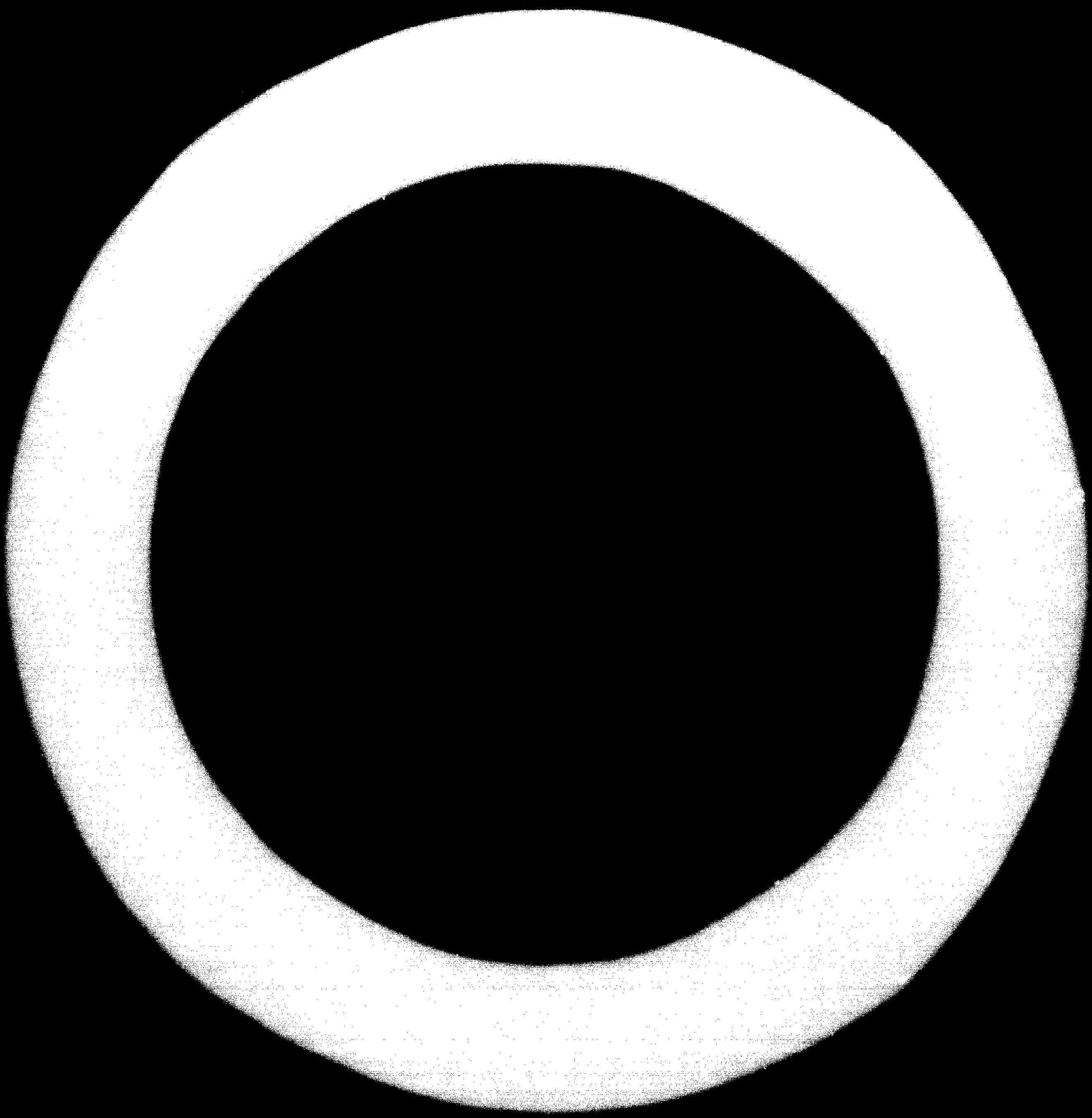
Après un chapitre d'introduction, dans lequel il expose brièvement l'évolution, des 20 dernières années, des systèmes automatiques de commande dans l'industrie, l'auteur en décrit la structure notamment en ce qui concerne les applications à l'automatisation des laminoirs à froid.

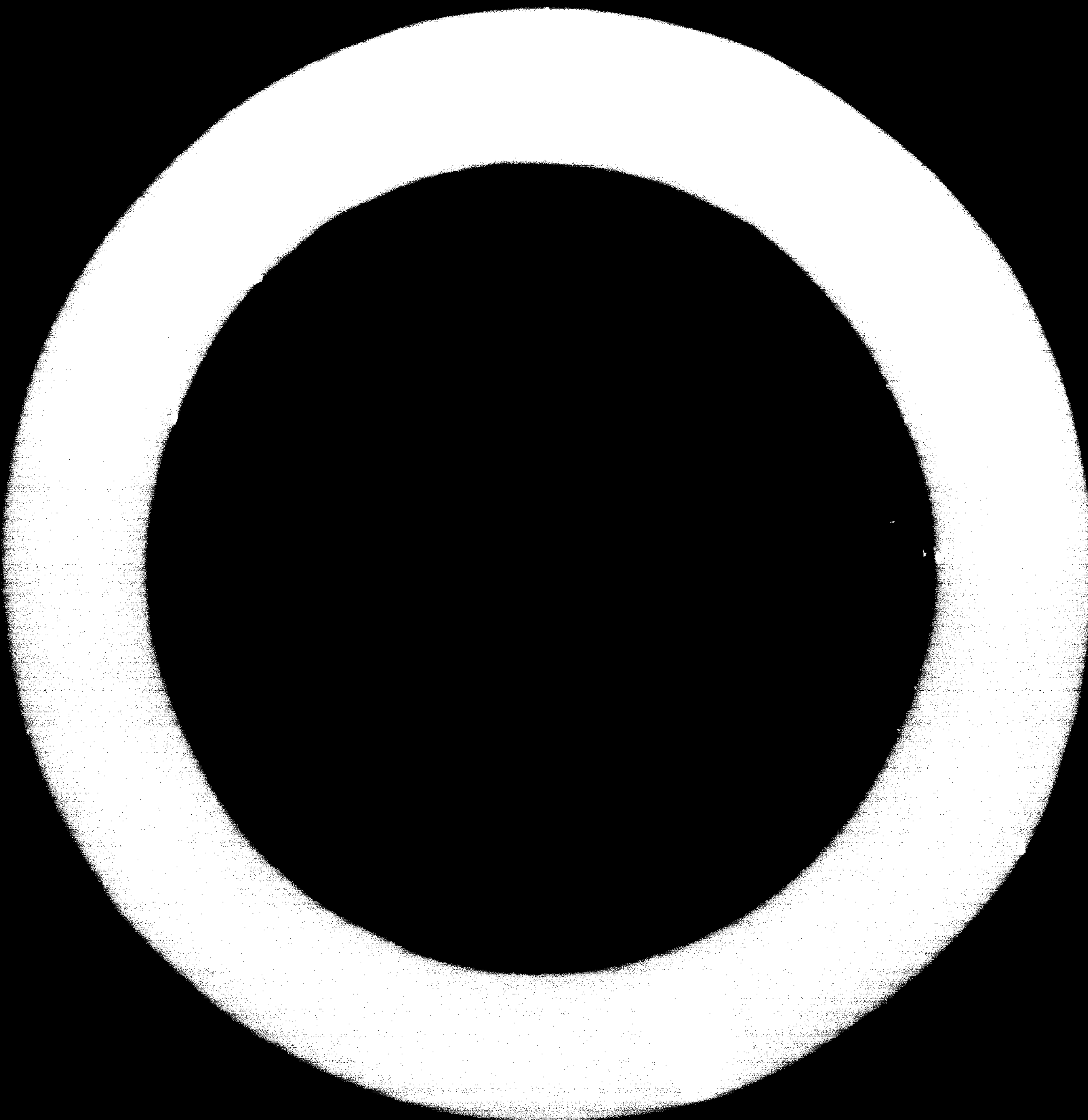
L'auteur examine ensuite l'importance et les applications des dispositifs de contrôle automatique de l'épaisseur des tôles (AGC) et présente une série de résultats d'expériences.

Les principes sur lesquels repose l'emploi d'un dispositif automatique de contrôle de l'épaisseur des tôles dans un laminoir à froid à cinq cages sont exposés en détail. Pour conclure, l'auteur recommande que tous les laminoirs à froid modernes soient

1/ Les opinions exprimées dans le présent document sont celles de l'auteur et ne reflètent pas nécessairement les vues du Secrétariat de l'ONUDI.

id.73-5265





dotés d'un dispositif de contrôle automatique de l'épaisseur des tôles. Grâce à cette technique on parvient à respecter une tolérance constante inférieure à -1 % dans l'épaisseur des tôles à vitesse constante, tolérance qui tombe à ±2 % en cas d'accélération ou de ralentissement. Par comparaison, l'emploi de commandes manuelles peut entraîner des variations de ±10 % par rapport à l'épaisseur nominale. Les avantages de la première méthode au point de vue coût sont considérables car la quantité de tôles mises au rebut ou déclassées diminue dans une forte proportion.

Un autre avantage résultant du contrôle précis de la tension de la tôle est qu'il y a nettement moins de ruptures et de pailles ce qui réduit sensiblement les arrêts des laminoirs.

- - - - -

S U M M A R Y

After an introductory section, which summarizes the growth of industrial automatic control systems in the past twenty years, the paper deals with the structure of control systems, with particular reference to their application for the automation of a cold rolling mill.

The significance and application of automatic gauge control (AGC) systems for controlling strip thickness are then discussed, and a series of experimental results are presented.

The philosophy underlying the application of AGC to a five-stand cold mill is considered at length. The paper concludes with the recommendation that no modern cold mill should operate without an AGC system. Consistent coil thickness tolerances of better than ±1% can be achieved under constant mill speed conditions, dropping to ±2% when accelerating or decelerating. These results compare with gauge changes that can be as much as 10% different from the nominal value during manual operation. This has tremendous advantages in cost savings, since the amount of rejected or downgraded product is considerably reduced.

Another advantage, resulting from the necessarily close control of strip tension, is that breakages and cobbles are considerably reduced. There is thus an appreciable reduction of mill down-time.

1. Introduction

The rapid growth of industrial automatic control systems in the past two decades is basically explained by the following three important developments :

a) Development of new electronic components.
b) Better theoretical understanding of many industrial processes, allowing their description by mathematical models.
c) Development and utilization of computers (process computers) in the control of processes and to collect and classify data.

In addition, the theory of Servomechanisms, or what is the same, the Theory of Feedback Control Systems, initially developed during the 2nd World War, received widespread attention and started to be utilized in the design of industrial control systems.

The marriage of the three technological developments above-mentioned with a better theoretical understanding resulted in an enormous growth in the control of industrial processes, so important that it has been called the second industrial revolution.

The first Industrial Revolution is characterized by the appearance of "muscular machines". The steam engine, the first of the series, is also the classical example of this period.

The 2nd Industrial Revolution is characterized by the "control". This word is not physically implemented by a particular machine or even by types of machinery; the physical counterpart of this word is much more sophisticated.

The "control" (of a variable, a process, an industry) is made possible by one or more appropriate control systems.
This can be defined as a set of components with a "defined structure" that actuate on a variable of a process and force it to assume desired values, despite disturbances that eventually affect the process.

The key concept in the above description is "defined structure". The internal constructive details of the components of a "control system" lose their importance but the function and structure (interconection) of these components become of paramount importance.

The Feedback theory shows that there is a common structure in all these systems and that they can be studied in a systematic way. The technology supplies the components to physically implement these structures. The result is systems with a complexity and presenting a performance difficult to be imagined until a few years ago.

In the following pages we will try to explain the basic structures common to all control systems. After that, we will show how the operation of a Cold Rolling Mill is controlled by these systems. Special emphasis will be given to the Automatic Gauge Control System (AGC), one of the more important control systems in a mill. The use of the Computer as a control component will briefly be discussed.

2. The structure of the Control Systems

As previously indicated, the function of a Regulator or Control System is to force one or more variables of a process (speed, temperature, gauge, etc.) to assume desired values, independently of disturbances that may eventually affect the process.

The "structure" of a control system, which is so important for its operation, is a direct consequence of two very simple but important concepts : measurement and corrective action.

In order to effectively control a variable it is necessary to constantly measure its actual value and to compare it against the desired value (reference). If there is a difference between the two (error), then the control system must be capable of initiating a corrective action actuating over the controlled process in order to drive the value of the controlled variable to the desired value. In other words the control system constantly acts to reduce the error to zero.

The "measurement" and "corrective action" can be represented by the drawing of Fig. 1.
This diagram clearly shows the comparison made between the measured and the desired values. Systems with such a structure are known as feedback or closed loop systems.

The opposite are the open-loop systems or systems without feed-back, which operate without measuring the controlled variable. Hence, such systems receive no information regarding the actual value of the controlled variable and thus are "blind" to any variation in its value; consequently they are unable to effect a corrective action if necessary.

All modern control systems operate in the closed-loop fashion.
A complex industrial process is controlled by many individual closed loops, each one being responsible for the control of a specific variable.

Automation of a Cold Rolling Mill

As an example of a process of definite interest we will now discuss the automation of a Multi-Stand Cold Mill.

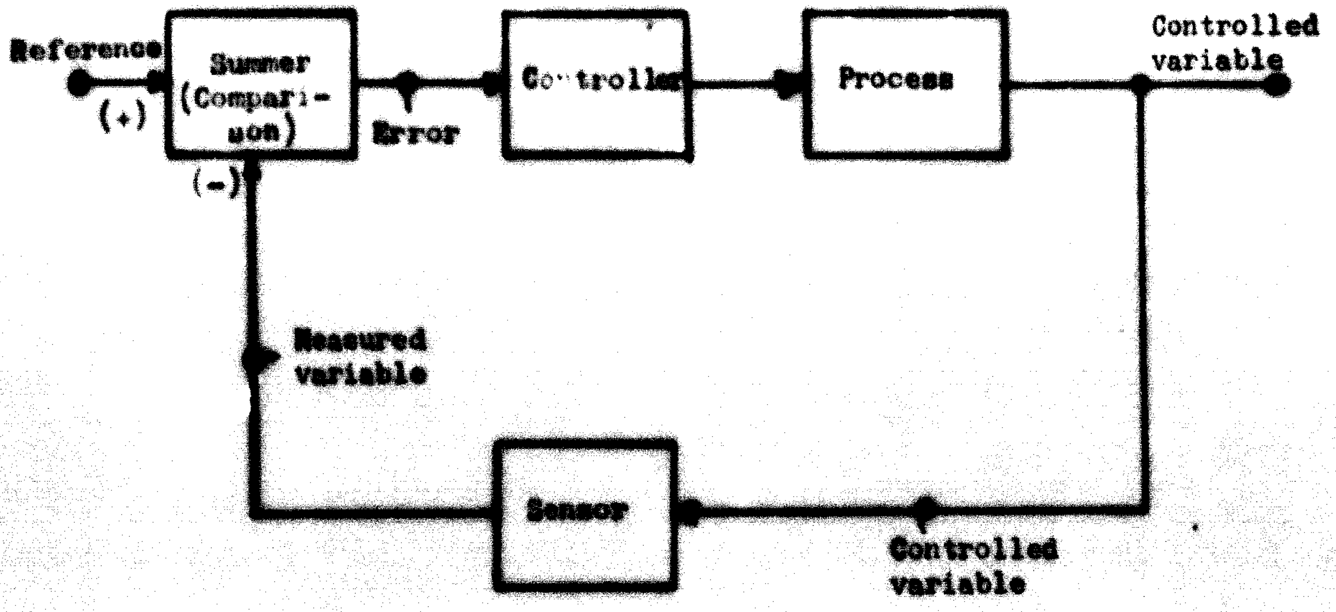


Fig. 1 - Common structure for all closed-loop control systems

To start, it is important to notice that there are many possible degrees of automation, depending on the number of functions that are transferred from the control of a human operator to the control of one or more Regulators.
For purposes of classification it is possible to recognize three basic levels of automation.

First level of Automation

At this level, at least the basic variables of the cold-rolling process (speed of the rolls,position of the screwdowns, tension on the winding and unwinding reels, gauge of the final product etc.) are controlled by appropriate regulators. However, it is the operator's responsibility to decide which value to chose for the reference of each regulator as well as the decision of when to change these references. The function of each regulator is simply to control its assigned variable and maintain it at the value determined by the reference, independently of eventual disturbances that may affect the rolling process.

Hence, before rolling, the operator choses the speed of each stand, the position of each screwdown, etc. which, based on his previous experience, he knows will produce a sheet with the desired characteristics and dimensions. This choice is made by adjusting the reference of each individual regulator, by means of manually operated rheostats located in a control desk.

Second Level of Automation

At this level,the references are also automatically adjusted. However, it is still the operator's responsibility to choose the correct values for these references.

In practice, such choice corresponds to the selection of a particular rolling

"Schedule" among various available alternatives, previously prepared and stored in a memory of some sort. In many cases the schedules are stored in a computer. Before rolling, the operator "calls" for a particular schedule, identifying it to the computer by a code number. The computer recognizes the code called, retrieves from its memory the values of the various references corresponding to that particular schedule, and adjusts the actual references of each regulator accordingly (set - point control). Hence, the computer performs the functions of schedule storage and of adjustment of the reference "rheostats". However, it is still the responsibility of the operator to select the correct schedule.

Although we have assumed that a computer is used at the 2nd level of automation, it is perfectly possible to attain this level without it.

The schedule storage can be made, for example, by a set of punched cards . The operator choses the desired schedule by selecting a card and inserting it in a card reader. The reference rheostats are then positioned by miniature motors in accordance with the values from the card. Although this alternative solution is perfectly acceptable, a computer is generally preferred because it can also be used for a number of other activities such as data logging, alarm monitoring, production logging, etc. Also, the computer can be used to implement one or more Regulators such as the screwdown position regulators, The Automatic Gauge Control, etc. In these cases the computer performs the functions of the "Summer" and "Controller" modules shown in Fig. 1, and operates in real time (on-line operation).

Third Level of Automation

Due to the great number of calculations and the complexity of the same, the use of the computer is mandatory to implement this third and highest level of automation.

In addition to the functions of reference storage and reference adjustment, the computer becomes also responsible for the correct selection of each reference. This is accomplished by the so-called "Schedule Calculation" function.

The operator informs the computer about the main characteristics of the incoming product (such as gauge, hardness, width) and the gauge desired for the finished product. With this data the computer calculates the values of the various variables of the process such as stand speed, interstand tensions, screwdown positions, etc. that will lead to a final product with the desired dimensions.

The "Schedule Calculation" is based in a mathematical model of the rolling process and is previously programmed into the computer.

Fig. 2 shows a 5-Stand Cold Mill and the Main Regulators that control it.

These are :

- Five speed regulators that individually control the speed of each stand.
- Five screwdown position regulators
- Four Interstand Tension Regulators
- Two Reel Tension Regulators
- One entry AGC System (controlling the Gauge after stand 1)
- One delivery AGC system (controlling the final product gauge)

This figure clearly shows the corresponding reference and feedback signals of each regulator.

We will now concentrate our attention in one of the more important (and complex) control systems of a rolling mill : the Automatic Gauge Control (AGC) System.

3. General Comments Concerning AGC Systems

3.1. Introduction :

As the name indicates, AGC are systems that automatically attempt to control the thickness (gauge) of a finished product in order to maintain it at a desired and constant value, independently of any changes or disturbances to the rolling process. Ideally, if the rolling process were free of disturbances, there would be no need for any automatic control of gauge. The operator would set-by experience or other-

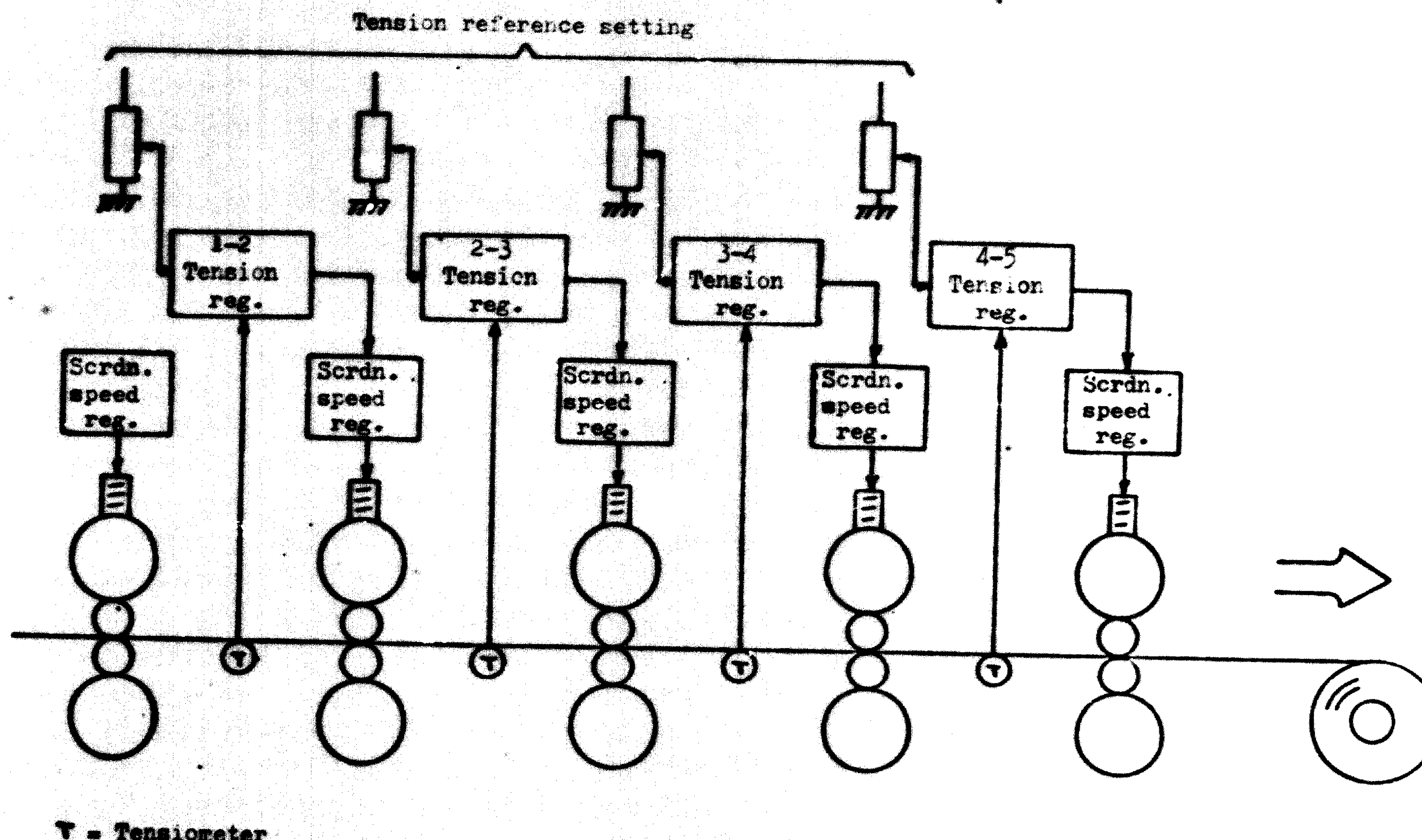


Fig. 2 - Screwdown interstand tension regulators

wise - the parameters of the mill (tensions, speeds, rolling forces, etc.), as required to obtain a desired thickness reduction for a particular coil and, assuming that no disturbances were present, the mill would then deliver the desired gauge throughout the full rolling of the coil. Unfortunately this is not the case, and the list of disturbing factors that affect the finished gauge is a long one. Among the most important we can mention :

a) Temperature - That changes the diameter of the back-up and work rolls and consequently affects the roll gap opening and the gauge. This is a slow-changing disturbance that is relatively easy to compensate for.

b) Roll Eccentricity - That periodically (the period depends on the mill speed) also disturbs the roll gap. At high mill speeds this disturbance can become very fast, making it extremely difficult to correct for.

c) Incoming Gauge Changes - Evidently the incoming gauge is far from perfect and the random deviations in thickness of the incoming product tend to produce the same type of gauge changes in the finished product. Among the most difficult to correct are the sudden and unpredictable changes in the incoming gauge caused by welds.

d) Mill Speed Effects - It has been consistently observed that when the speed of a cold mill is increased, the delivery gauge gets noticeably thinner, even if there is no change in the incoming product. The reverse (delivery gauge gets thicker) happens when the mill speed is decreased.

The mechanism responsible for this effect is not quite well understood. One possible explanation is the increase in the oil film in the bearings of the rolls that would cause the roll gap to be reduced when the mill speed is increased. However, the oil film effect on the bearings can be measured when the mill is unloaded

(no metal in the mill) and, although these measurements are not very accurate, they seem to indicate that the oil film is only partially responsible for the mill speed effect on gauge.

Another theory tries to explain the reduction in gauge with an increasing mill speed as being caused by a reduction in the coefficient of friction between the metal and the work rolls. This would result in less energy losses - under heat form - at the roll bite, increasing the efficiency of the reduction process and consequently causing the gauge to go thinner.

Still another explanation theorizes that a "wedge" of coolant, carried by the strip, interposes itself between the metal and the work rolls, actually decreasing the roll gap. More coolant would be carried at higher mill speeds, explaining the progressively thinner gauge.

Possibly all of the above mentioned factors and some other not listed (as, for example, a possible shift in the center-line of the work rolls in relation to the back-up rolls) combine themselves and together contribute to the observed decrease in gauge when the mill speed is increased.

The "Speed Effect" is particularly important in Cold Mills that, for every coil, are accelerated from zero to top speed in a few seconds.

The mill speed effects can be classified as "moderately fast" disturbances to the delivery gauge.

As can already be seen, the list of disturbances to the finished gauge is truly a long one, and can easily be increased. Changes in the coolant composition and temperature, variations in the hardness of the incoming product, variations in the front or back tension of the strip, etc., all affect the delivery gauge in various degrees.

Hence, the first step to be taken in order to obtain a good final gauge is to reduce to a minimum the changes in the rolling variables over which one has any control. Thus, the rolls should be carefully ground, the front and back tensions should be precisely controlled by good tension (or current) regulators, the coolant composition should be maintained as uniform as possible, etc.

After these preliminary steps are taken, the next step is to design some kind of a system able to recognize any gauge deviation from a desired value (error) and capable of initiating corrective measures to restore it to the required value. More explicitly, any AGC system has to perform two kinds of functions :

a) To detect (sense) any deviation in the delivery thickness from the nominal (desired) value.

b) To initiate some kind of corrective action, by manipulating one or more variables (controlled variables) that affect gauge, in order to force it to return to the desired value, independently of the factor initially responsible for the gauge disturbance.

From the above, it is apparent that an AGC system is basically similar to any conventional closed-loop control system, and has the same "structure" described in Section II.
However, a number of practical difficulties arise, that create problems typical to an AGC and not found in the more conventional regulators.
One of the most important is the so called "Transport Time" which we will now analyze.

3.2. Transport Time

The main stumbling block for the operation of an AGC is the difficulty of measuring the gauge deviations at the moment they occur (at the roll bite).

Due to mechanical and space problems, the gaugemeter sensing head, generally an X-Ray, has to be always mounted some distance away from the roll bite. Hence, when gauge deviations occur at the gap, they are not detected immediately but only after the strip has travelled from the roll gap to the sensing head.

This delay in measurement is known as "transport time" delay. Typically, the X-Ray measuring head is mounted at a distance of four to six feet from the roll bite.

Evidently the "transport time" depends not only on this distance, but also on the delivery speed of the mill. It is given by the expression :

$T = \frac{D}{v}$ where : T = transport time

D = distance from the X-Ray head to the roll bite.

v = Strip speed.

This delay in measurement evidently also delays any necessary corrective action and creates serious difficulties for the good performance of an AGC system. Recently a new method has been developed that practically solves the problem represented by the "transport time". It is known as AGC with compensation for "transport time."

This method <u>predicts</u> the gauge exiting the roll bite by measuring the actual gauge under the gaugemeter head <u>and</u> the <u>trend</u> of change in gauge.

The results obtained with the "Compensated AGC" are excellent and are shown in Figs. 3a-f, which are charts taken on a single-stand cold mill.

3.3. Screwdown & Tension AGC - Experimental Results :

The recordings shown in Figures 3a and b were taken in a Single -

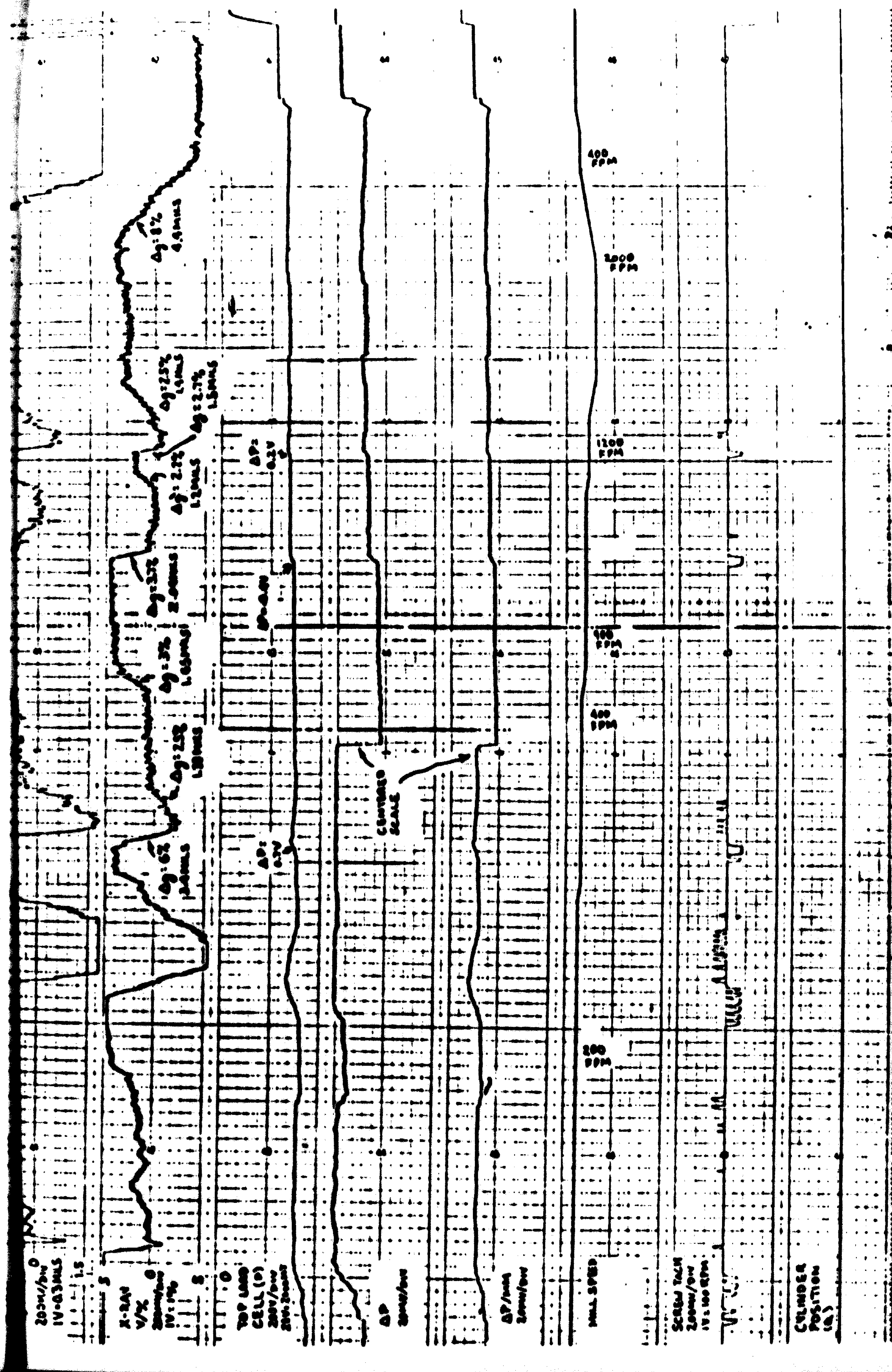
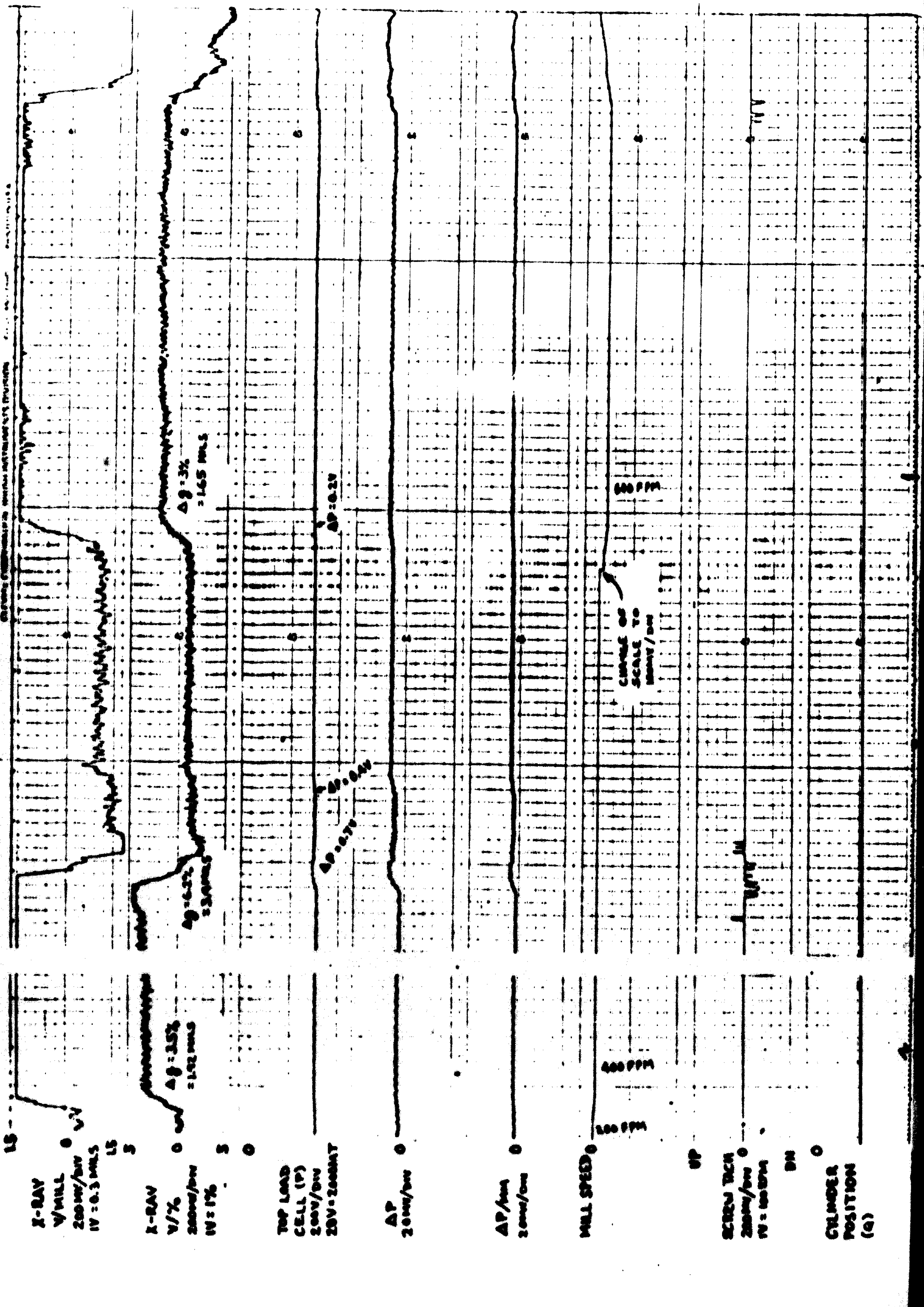


Fig. 3a - All gauge-control systems off


X-RAY
V/MILL
X-RAY
V/%
TOP LOAD
CELL (P)
ΔP
ΔP/mm
MILL SPEED
SCREW TACH
CYLINDER
POSITION
600 FPM
400 FPM
200 FPM
UP
DN

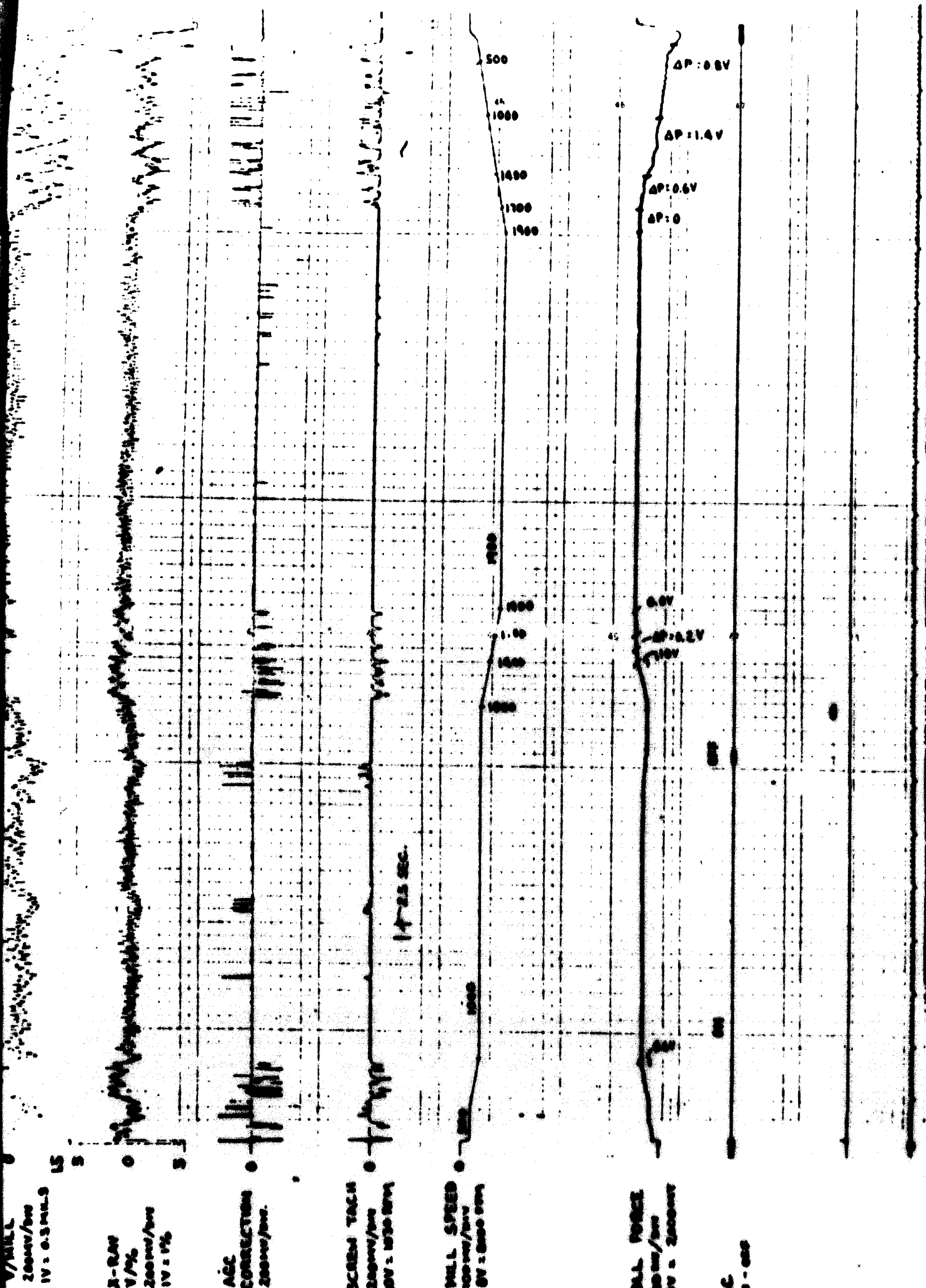


Fig. 3c - Screwdown AGC : transport distance = 5.5 ft

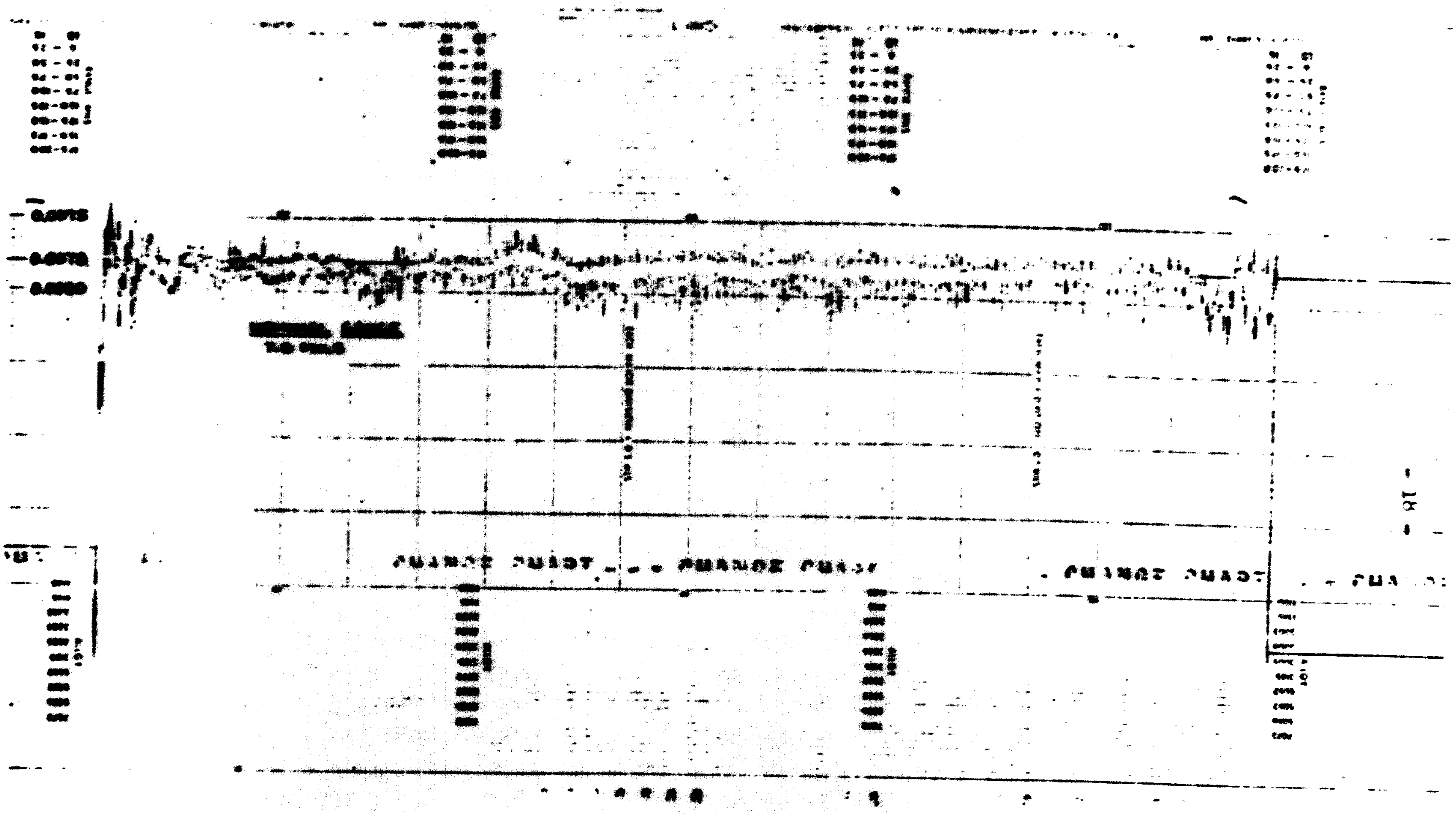


Fig. 3d – Single-stand aluminium cold mill. Screwdown and tension AGC : transport distance = 3 ft

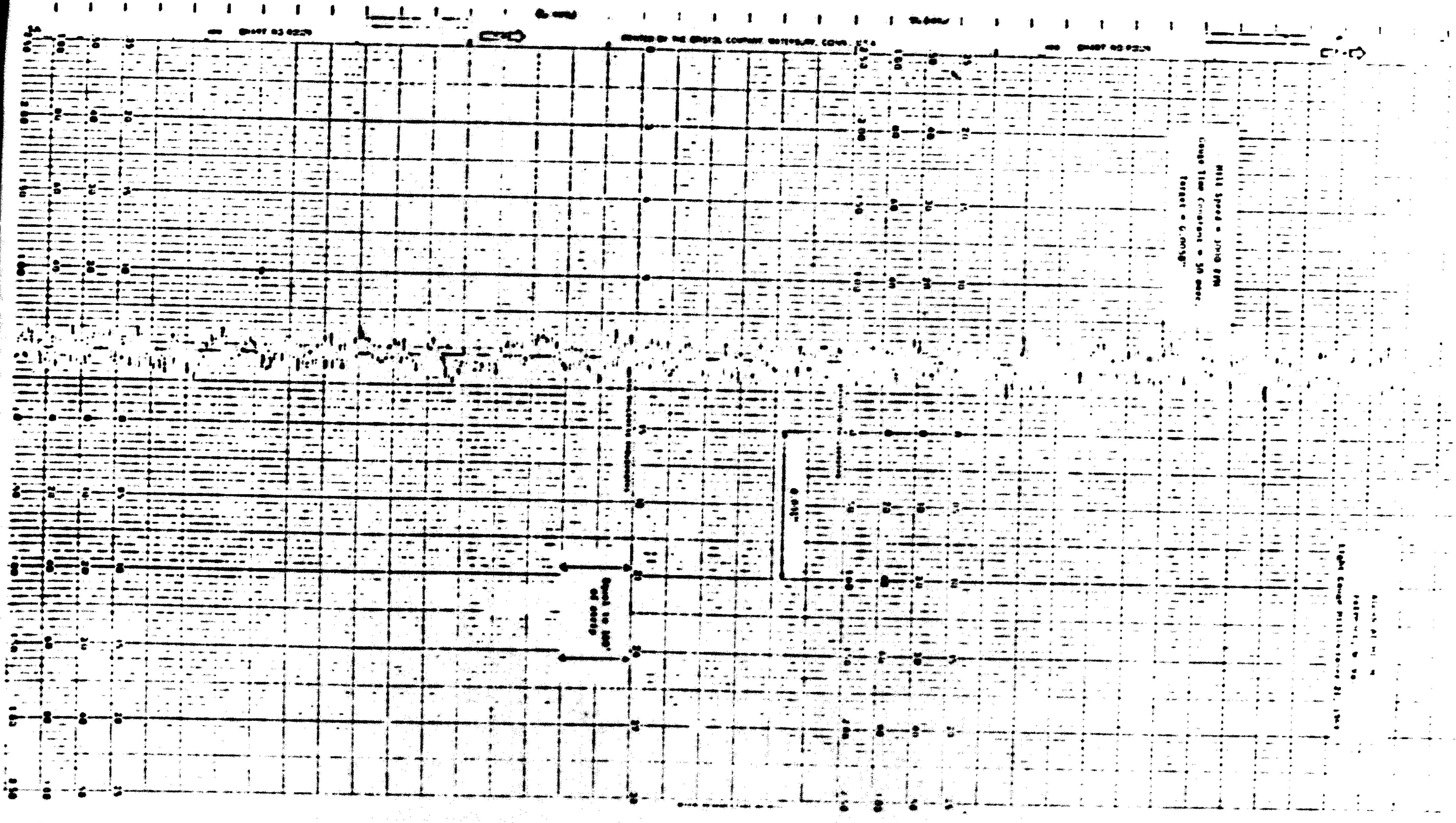


Fig. 3e - Single-stand aluminium mill. Screwdown and tension AGC : Transport distance = 3 ft, gaugemeter response time = 50 msec

PRODUCT: Alcan Foil Stock
CHARACTERISTIC: 50 millisecond T C
DATE SAMPLED: 10/21/69
COMPUTED BY: Douglas A. Bar.
DATE: 11/14/69

VALUE	NUMBER FOUND AT EACH VALUE	f	d	fd	$f(d)^2$
			15		
			13		
			12		
			11		
			10		
			9		
6.000			8		
5.975			7		
5.950			6		
5.925			5		
5.900			4		
5.875	X	1	3	3	9
5.850	X X X X X	5	2	10	20
5.825	X X X X X X X X X X X	11	1	11	11
5.800	X X X X X X X X X X X X	12	0	0	0
5.775	X X X X X X X X X	9	-1	-9	+9
5.750	X X X X X X	6	-2	-12	+24
5.725		0	-3	0	+0
5.700	X	1	-4	-4	+16
5.675			-5		
5.650			-6		
5.625			-7		
5.600			-8		
			-9		
			-10		
			-11		
			-12		
			-13		
			-14		
	N →	45	Σ+ →	24	
			Σ- →	25	
			Σ fd →	-1	
			$\Sigma f(d)^2$ →		89

INTERVAL	LIMITS FROM	LIMITS TO	% OF DATA INCLUDED
$\bar{X} \pm \sigma$			
$\bar{X} \pm 2\sigma$			
$\bar{X} \pm 3\sigma$			

SYMBOLS

- $\bar{X}$ = TRUE MEAN
- AM = ASSUMED MEAN
- Σ = "TOTAL" OR "SUM OF"
- σ = STANDARD DEVIATION
- N = TOTAL OBSERVATIONS
- f = FREQUENCY

AVERAGE

$\bar{X} = AM + C\frac{\Sigma fd}{N}$

$C = .025$

$AM = 5.800$

$\frac{\Sigma fd}{N} = \frac{-1}{45} = -.02$

$C\frac{\Sigma fd}{N} = .025 \times -.02 = -.0005$

$\bar{X} = 5.799$

RESULTS

$\bar{X} = 5.79$

$\sigma = 0.035$

STANDARD DEVIATION

$\sigma = C\sqrt{A - B} = C\sqrt{\frac{\Sigma f(d)^2}{N} - \left(\frac{\Sigma fd}{N}\right)^2}$

$A = \frac{\Sigma f(d)^2}{N} = \frac{89}{45} = 2$

$B = \left(\frac{\Sigma fd}{N}\right)^2 = (-.02)^2 = .0004$

$A - B = 2.000 - .0004 = 1.9996$

$\sqrt{A - B} = 1.410$

$\sigma = 1.410 \times .025$

$\sigma = 0.035$

Stand Aluminum, with the operator trying to control gauge manually by operating in the screwdown. These recordings clearly show the "speed effect" on gauge and the fact that the roll force (P) is completely unchanged when the gauge decreases due to an increase in the mill speed. It is important to notice though that, whenever the operator moves the screws, there is immediately a change in roll force as should be expected.

For comparison, Fig. 3c shows a coil in the same mill with the screwdown AGC in operation. The distance between the X-Ray head and the roll bite is 5.5 ft. for this mill. The tension AGC was not operative at the time this recording was taken, but better results yet were obtained with both systems working together.

Figure 3d shows the performance obtained with the Screwdown & Tension AGC in a Single-Stand Aluminum Mill that has the X-Ray mounted quite close to the roll bite (3 ft.). This makes the "transport time compensation" very effective. The performance shown is consistently obtained and percentage-wise it is even better for thicker products.

Figure 3e shows a recording taken to conduct a statistical analysis of the AGC performance and of the influence that the gaugemeter (in this case a β-Ray type) response time has on gauge. The final product gauge was actually checked by micrometer measurements, to verify that the correct thickness was being read by the gauge - meter. The reader should notice the beginning of some instability when the gaugemeter time constant is 100 m sec.

Figure 3f is an statistical analysis of the coil of Fig. 3e. The desired gauge is 5.400 mils (target value). Notice that the actual gauge is always within the band 5.750 mils to 5.875 mils with the target value being reached (zero deviation) 12 times out of 45 measurements.

The results evidently are very good and are consistently obtained.

The AGC with "Compensation for Transport Time" can be utilized in single stand or multi-stand units. In this last case it becomes part of a multiple and coordinated system whose objective is to maintain the final product gauge within close tolerance.

In the next item we will briefly present the AGC system for a 5-Stand Cold Mill.

4. Philosophy of AGC for a 5-Stand Cold Mill

In a multi-stand mill there are many variables that can be used to control gauge. In the particular case of a 5-stand mill there are fifteen (15) different variables (five screwdown positions, five back tensions, and five stand speeds) that can be manipulated in different ways, all affecting the final delivered product. To make the situation more difficult, these variables are not independent but interact with each other; thus, a change in a stand speed not only affects gauge but also changes inter-stand tension and pressductor roll force; a change in the screwdown position affects roll force and back tension but does not affect gauge, etc.

At the present, there is quite a sizeable amount of theoretical and practical knowledge available to the AGC designer and this knowledge has reached a point where it is possible to predict, fairly accurately, how a mill and its final product will react when a certain approach for gauge control is chosen. Still, there are a number of areas where an understanding of the processes involved - especially a theoretical understanding - is far from complete.

Due to the large number of variables available for gauge control in a Multi-Stand Mill the "philosophy" of gauge control acquires paramount importance.

This philosophy has been evolving throughout the years, as more insight is gained about the rolling process and the relationships that describe the various interactions among the different variables.

In this paper we will describe the system we presently consider to be the most desirable although recognizing that other acceptable approaches exist. No attempt will be made to justify this philosophy, although this can certainly be done.

As new developments take place, especially in the area of strip speed measurement, the philosophy of gauge control will certainly evolve again. It is important, then, to keep in mind the fundamental ideas that support any consistent approach to the control of gauge in order to be able to apply and take full advantage of future developments.

4.1. Interstand Tension - Some Considerations

Since back tension has an important effect on gauge, any AGC system for a Multi-Stand Mill depends intimately on the way the interstand tensions are controlled and/or changed. In a Single-Stand Mill the situation is quite straight forward since the current (or tension) regulators of each reel accurately maintain constant the front and back tensions.

In a Multi-Stand mill the situation is quite distinct. Here, the stand speeds are the variables that are maintained constant by each stand speed regulator. However, it is also highly desirable, not only for a good control of guage but also to avoid breakages or loops, to be able to control the interstand tensions. Once this fact is recognized the first major decision immediately presents itself to the AGC designer and user : which variables should be manipulated to control the interstand tensions?

Basically either the screwdown positions or the stand relative speed will affect the interstand tension.

The theory shows and the practical experience confirms that the best method to control the interstand tensions is by actuating in the screwdown position, leaving the stand speeds undisturbed.

Hence, a 5-stand mill will have four interstand tension regulators each one actuating in the screwdown position of the adjacent "down-stream" screwdown.

This is shown in Fig. 4.

After the interstand tensions have been controlled, the next step is to actually control the delivery gauge. Here, again, there are many possible alternatives available. In the author's experience the method that has shown the best results is the one that uses two AGC systems :

a) One AGC system to control the gauge exiting stand 1 by changing the number 1 stand screwdown position.
   The actual gauge is measured by an X-Ray mounted after stand 1, and operating with a "Compensated AGC system".

b) One AGC system to control the final gauge by changing the stand 5 speed. The delivery gauge is measured by an X-Ray mounted after stand 5.

To summarize, a complete AGC system for a 5-stand Cold Mill is composed by the following six subsystems :

a) Four interstand tension regulators
b) One entry AGC
c) One delivery AGC

These subsystems operate together in a coordinated fashion to obtain the

NOTES: ① RELAY "TH" IS ENERGIZED ABOVE THREAD SPEED SWITCHING THE TENSION REG. TO SCREWDOWN MODE.
② REMOVE LINES MARKED △ AND ADD DOTTED LINES MARKED ☒ FOR OPERATION W/O MOVING #5 SCREWS.

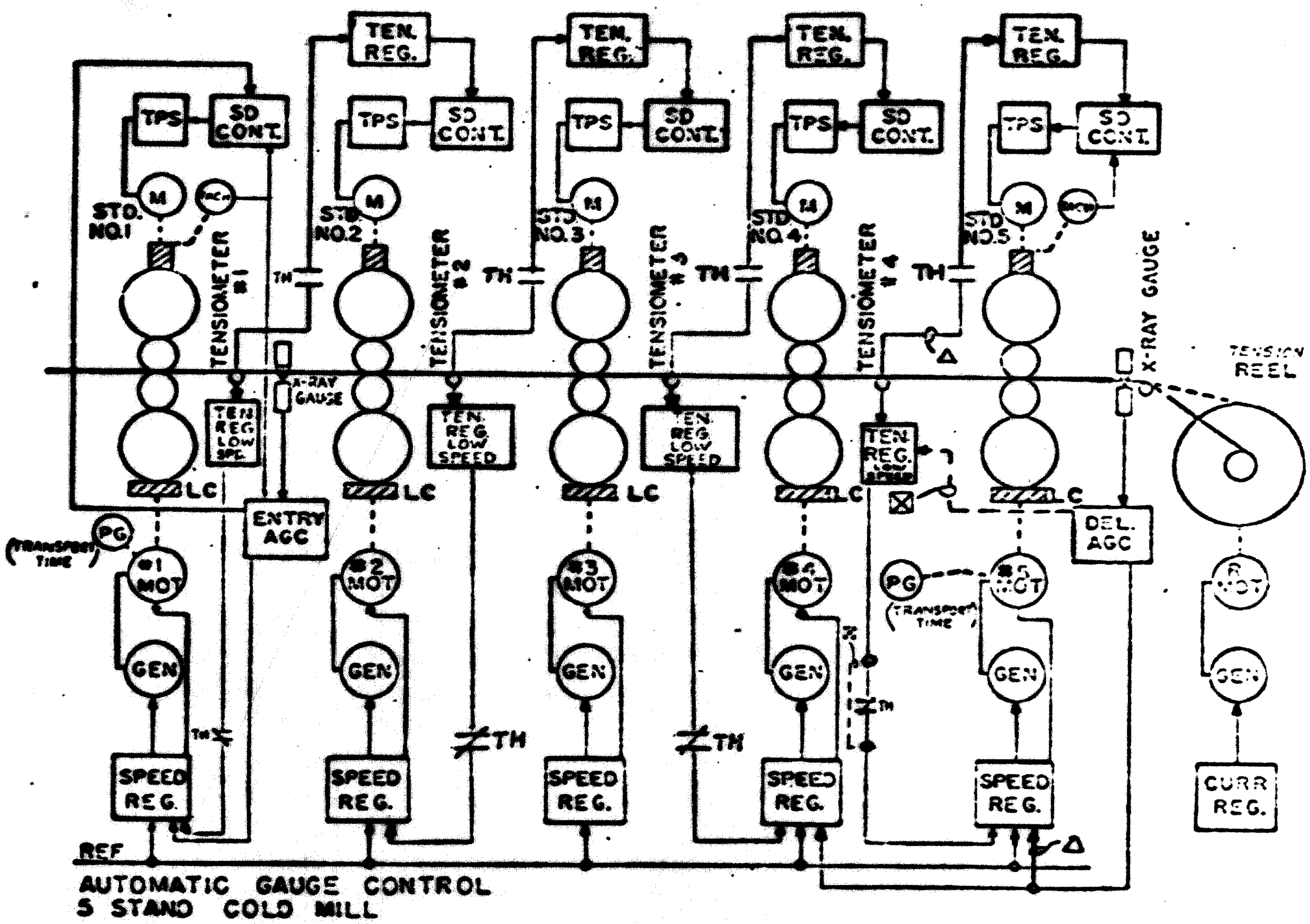


Fig. 4 - AGC and tension systems

the best possible gauge under changing rolling conditions.

5 - Results and Conclusion

No modern Cold Mill, either single or multi-stand, can afford to operate without an AGC system.

A manually controlled mill very frequently shows gauge changes of more than 10% from the nominal value. What is worse, the results are not consistent since it is impossible for any operator to dedicate full attention to the gauge during his working shift.

With modern AGC systems it is possible to consistently roll coils with a tolerance better than ± 1% under constant mill speed conditions, dropping to ± 2% when the mill is being accelerated or decelerated.
These results are consistent, and obtained coil after coil.

It is easy to imagine the savings in cost that this represents, preventing the possible rejection of entire loads due to the product not meeting the required customer specifications.

In addition, the necessarily close control of the strip tension substantially reduces the number of breakages or loops.

The mill down-time is kept to a minimum, resulting in appreciable increase in the production. Hence, the use of an AGC system presents two direct advantages to the user :

a) Better product quality
b) Higher production.

[redacted]

9. 8. 74