

PL-560

AccuRay

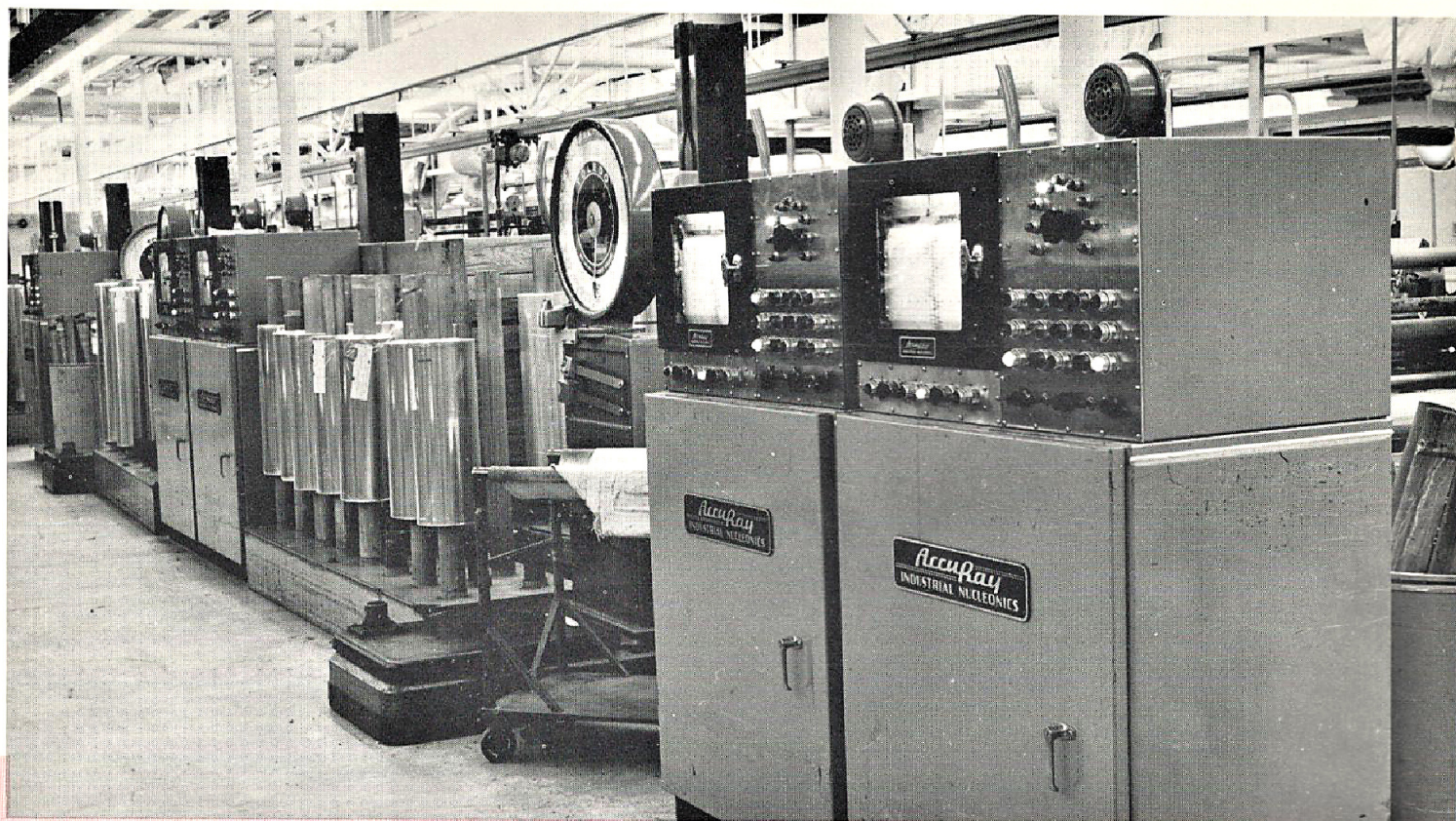
Extruder Measurement and Control Systems..

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***I*ndustrial
*N*ucleonics**
CORPORATION

650 Ackerman Rd.
Columbus 2, Ohio

The WORLD'S LARGEST Manufacturer of Nucleonic Industrial Process Control Systems



the *AccuRay*® Dimension

The formula for profitable processing of raw materials into high quality finished product is the preciseness of measurement and control employed during manufacturing. Today, in over 100 varied plastics extruder installations, AccuRay Extruder Control Systems are assuring highest possible quality of production and, at the same time, saving thousands of dollars in raw materials and costs of producing.

Specific areas of economic and production results found with AccuRay Extruder Control Systems are:

1. Improved uniformity of product
2. Greater yield:
 - a. More feet per pound of raw material
 - b. Reduction of scrap
3. Increased productivity:
 - a. More throughput per year of salable material
 - b. Faster startups and specification changes
4. Engineering and trouble shooting:
Measurement equipment quickly detects process malfunctions and helps to identify cause of trouble.

To understand how these benefits are obtained it is necessary to examine (1) the principle of measurement and control utilized in the AccuRay Extruder Control System, and, (2) thickness variations inherent in plastic extruder processing.

PRINCIPLE OF MEASUREMENT

Using a stable long lived radioisotope, the AccuRay Measuring System provides a non-contacting, continuous, and accurate measurement of the moving sheet. Reproducible measurements to one millionth of an inch are readily obtainable. Automatic standardiza-

tion each half hour eliminates errors in measurement due to conditions in the air gap, temperature, atmospheric changes, dust, etc. Since most AccuRay Extruder Systems continuously scan the sheet, a truly representative measurement of the web or sheet is obtained.

CONTROL OF PRODUCT VARIABLES

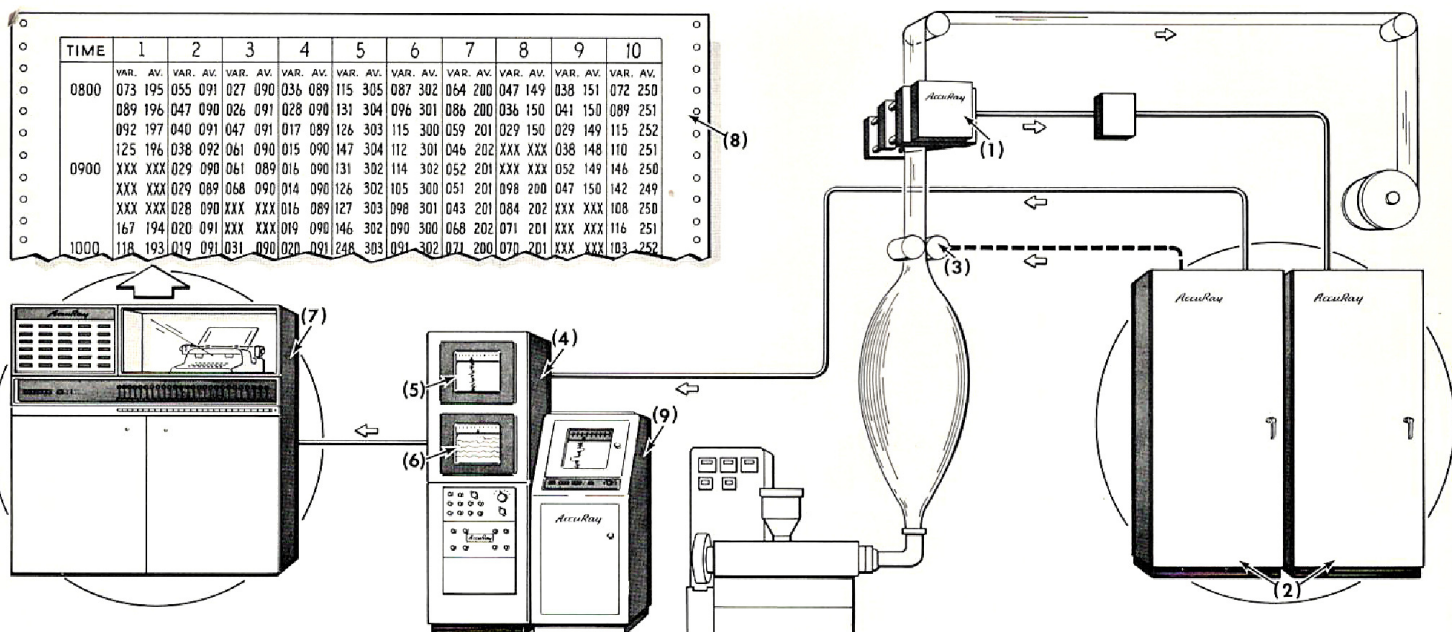
In the plastic extruder process three significant thickness variables must be measured and then controlled to produce the desired uniformity of film. These are:

(1) *Long Term Machine Direction Variations:* Long term variations are those occurring at longer intervals than required to enact control from the point of measurement. A unique feature of the AccuRay Extruder Control System is its ability to scan and average the thickness of sheet for a constant time period equal to the approximate system transportation lag. The system thereby automatically controls long term variations through the closed loop feedback principle.

(2) *Short Term Machine Direction Variations:* In contrast to long term variations, short term variations occur more frequently and in shorter time intervals than can be corrected by feedback control. Normally the operator is not immediately aware of their presence. AccuRay continuous measurement provides a graphic representation of short term variations on a recorder chart. By observing these surges and cyclical variations on the chart the operator may make process corrections immediately to reduce short term variations to a minimum period.

(3) *Profile Variations:* Since the AccuRay Extruder Measurement System continuously scans the sheet, profile variations appear immediately on a standard strip or X-Y Recorder. Improper die adjustments or extruder malfunctions affecting profile are detected instantaneously.

AccuRay Data and Control System



in Plastics Extrusion

An integrated AccuRay Measurement, Automatic Control, Data Processing, and Readout System for plastic extrusion.

As shown in the drawing above, continuous, accurate, non-contacting measurement of product variables is the cornerstone upon which integrated AccuRay Data and Control Systems are engineered.

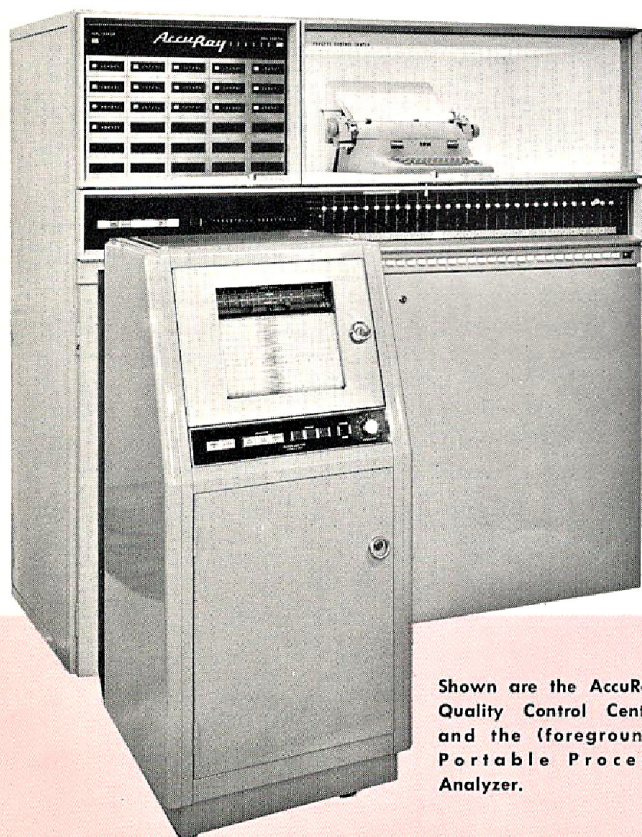
Thickness measurement of the sheet is relayed by the AccuRay gauge (1) to remoted consoles (2) which prepare the signal for control action, data reduction and readout.

Automatic control (3) of long term variances is achieved through speed adjustment of take away rolls, extruder screw, or other process control devices. Patent No. 2,922,188 and other patents pending.

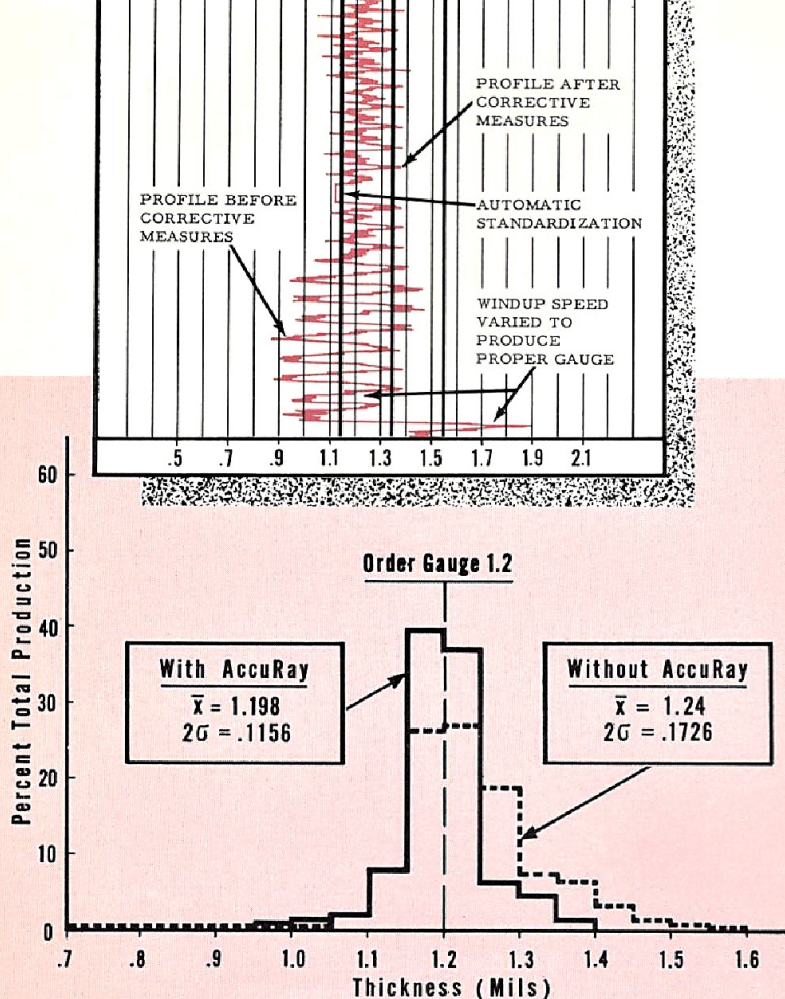
The sheet thickness measurement is also relayed to the Operator's Station (4) where weight variations are presented on a strip chart recorder, (5) and, also, on a X-Y Type Profile Recorder (6) for presentation of across-the-sheet weight variations.

The AccuRay Quality Control Center (7) is a data reduction and readout computer providing operational and management personnel with statistical quality control data from as many as 30 individual extruders. The Quality Control Center determines and reads out average thickness or mean, and combined short term and profile weight variations from each machine. As shown in the statistical form, (8) variance (σ^2) is printed in one column, average thickness (\bar{x}) in the other. X indicates down time. When either variance or average weight thickness exceed predetermined limits an alarm identifies the faulty extruder.

When an off tolerance variance is indicated, trouble shooting personnel utilize the Portable Process Analyzer (9) to localize the machine faults and return the unit to peak efficiency.



Shown are the AccuRay Quality Control Center and the (foreground) Portable Process Analyzer.



Since the trend in production of blown polyethylene film is directed toward faster take off speeds, larger extruders, and larger diameter bubbles, control of the process is today more essential than at any other period in the industry's history.

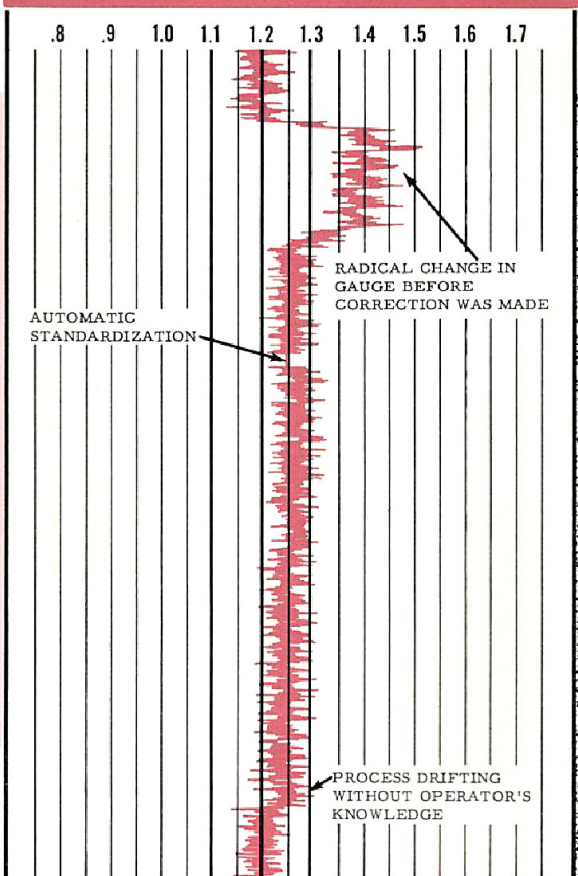
As illustrated by the charts on this page, product quality is remarkably improved with the installation of AccuRay Extruder Measurement and Control Systems. A study of quality improvement on a number of varied extruder installations reveals average profile improvement to be 30%.

In a typical case study (results shown below) an evaluation was conducted before and after installation of an AccuRay Extruder Measurement System on an extruder producing polyethylene film of .0012 in. thickness. Improvement in this instance, was obtained without automatic control; the operator referred to recorder charts to manually control the process.

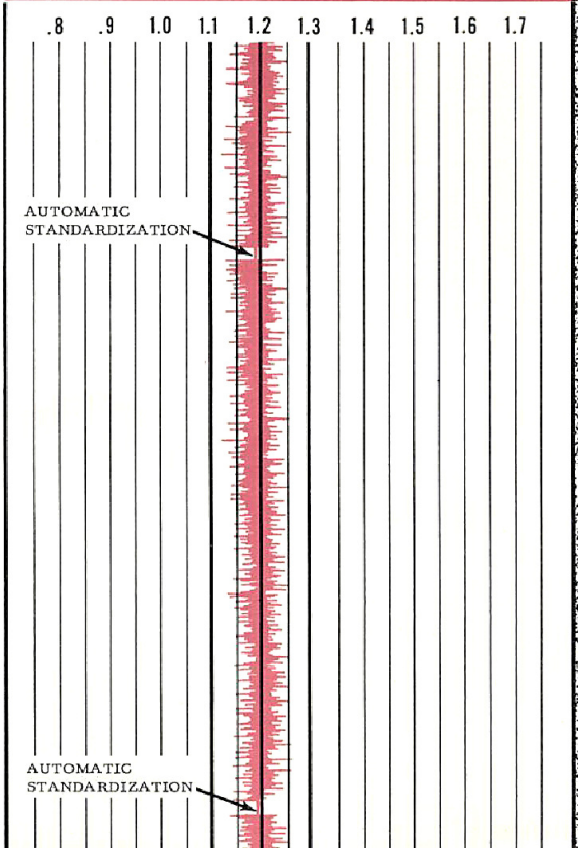
Product Quality	Without AccuRay	With AccuRay
Firsts	73.1 %	84.3 %
Seconds	6.2 %	3.5 %
Scrap	20.7 %	12.2 %

Annual savings on this extruder after installation of the AccuRay System amounted to \$29,000 in terms of reduced scrap, greater throughput and raw material savings.

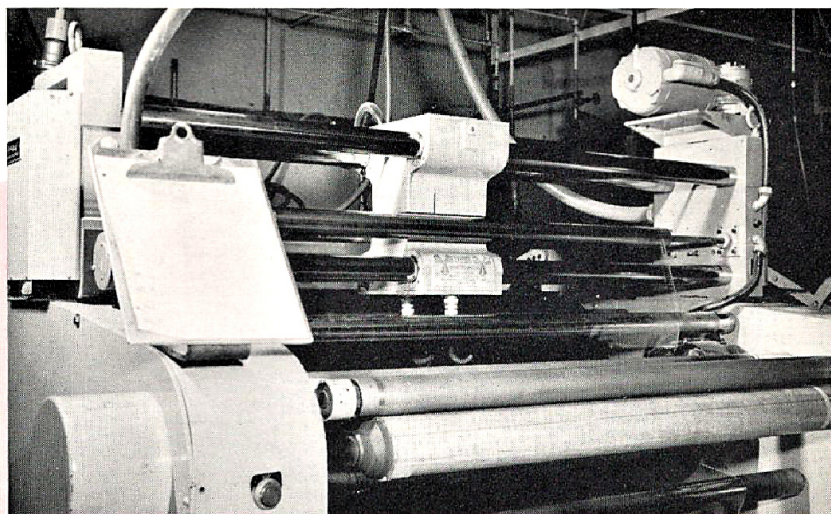
WITHOUT AccuRay CONTROL



WITH AccuRay CONTROL



For Extruded Blown Film Processing



The Dow Chemical Company uses AccuRay Measurement and Control Systems to automatically control its Saran Wrap extruders producing film of double thickness down to 0.001 inch.

Remote Operator's Station and Automatic Control Bay located adjacent to the process for operator convenience.

AUTOMATIC CONTROL OF EXTRUDERS PAYS DIVIDENDS IN INCREASED PRODUCTION

As mentioned earlier in this brochure thickness or weight variations may be classified into 3 categories; profile, short term, and long term machine direction variations. While it is difficult to automatically control profile and short term variations, long term variances can be automatically controlled with a feedback or closed loop measurement-control system.

In an AccuRay Measurement and Control System for extruded film the scanning and averaging measurement signal is relayed by the gauge to the recorder where it is compared to desired target. Any deviations from target will be received by the auto-controller, which, in turn, sends a corrective signal to the actuator controlling the process. In an extruder control system this would be by adjustment of either the screw or take-away speed.

The justification for automatic control of an extruder can be directly related to a number of benefits, the most important of which is increased through-put and yield.

$$\text{Rate (pounds/hr)} = \text{Take away speed (ft./hr)} \times \text{Width (ft.)} \\ \times \text{Density (\#/ft.}^3\text{)} \times \text{Thickness (ft.)}$$

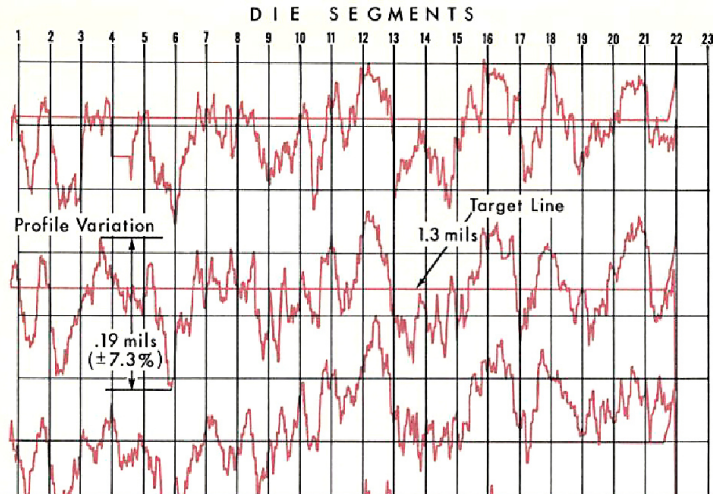
As shown in the equation above, Extruder Production Rate is dependent upon the relationship of Take-Away Speed, Width of Sheet, Density, and Thickness.

Under normal extruder operation, Take-Away Speed, and Density are constant values, thus, Production Rate and Thickness must vary in a linear manner. Therefore, contrary to popular opinion, since

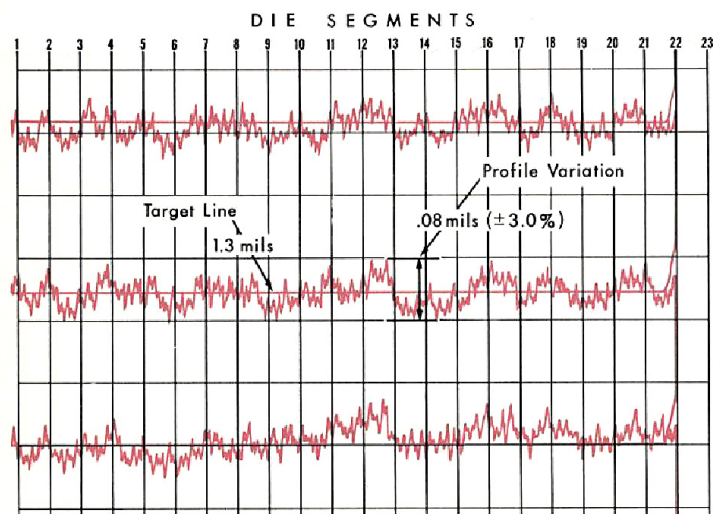
film thickness varies considerably during extrusion, the pounds per hour through-put will vary in the same proportion. From the above it is determined that extruder production rate is limited to the degree of control maintained on sheet thickness.

An example of this relationship is shown in a typical Performance Table reproduced below. This study taken at a plant producing blown film represents production rates from a significant number of extruders. Automatic control averaged 10.9% more production per hour than manual control.

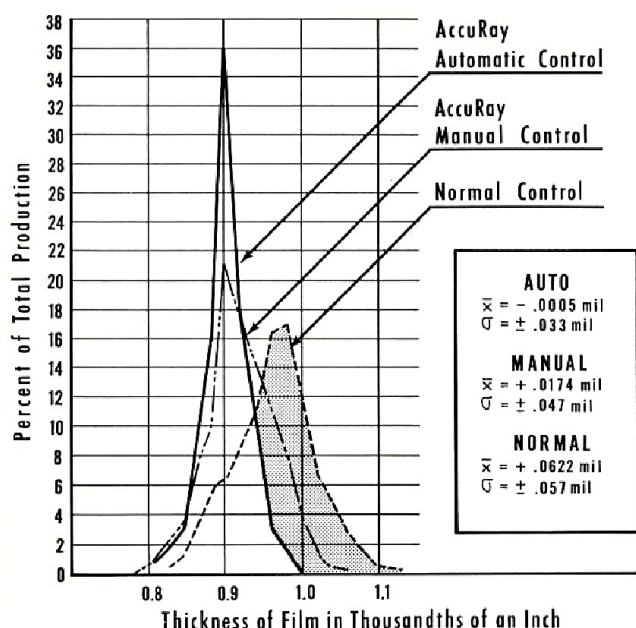
	Target	\bar{X}	3σ	lbs/hour
Manual	.0010 inches	.001030 inches	.000144 inches	143.0
Automatic	.0010 "	.001011 "	.000080 "	158.0
Manual	.0012 "	.001220 "	.000144 "	140.5
Automatic	.0012 "	.001203 "	.000084 "	149.3
Manual	.0015 "	.001482 "	.000219 "	129.4
Automatic	.0015 "	.001505 "	.000138 "	141.7
Manual	.0020 "	.002038 "	.000246 "	107.1
Automatic	.0020 "	.001999 "	.000205 "	118.2
Manual	.0040 "	.004056 "	.000510 "	87.1
Automatic	.0040 "	.003987 "	.000465 "	94.5



Profile Without *AccuRay* Control

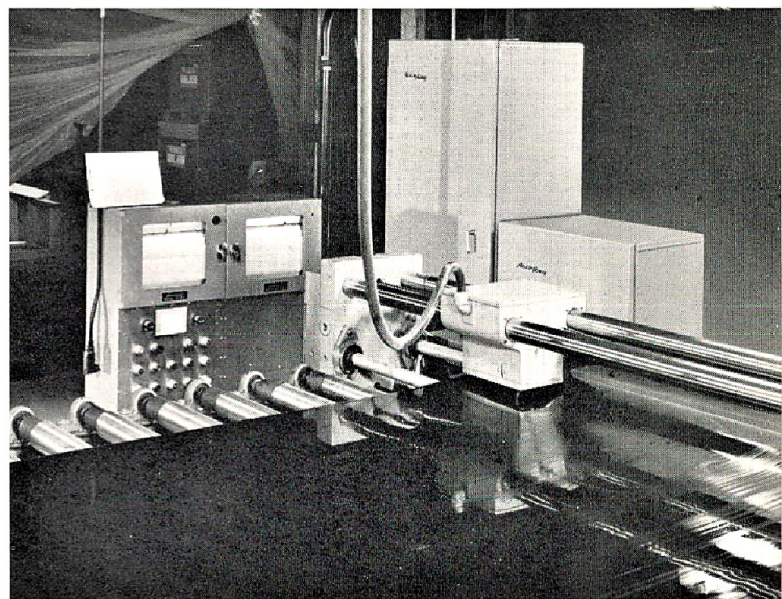


Profile With *AccuRay* Control



Extruded Film Thickness Distribution

AccuRay® Extruder



The AccuRay Measurement and Control System at Amplex Corporation maintains uniformity of 1/8" Acrylic sheeting. Vice President, J. Benkin says, "We are well satisfied with the economic justification of our AccuRay System and the improved quality it enables us to deliver to our customers."

REDUCE PROCESSING COSTS...and, at the same time,

FLAT DIE EXTRUDED FILM

The economic benefits enjoyed with an AccuRay Extruder Measurement and Control System on Flat Die Extruded Film are found in a number of specific areas. Since system evaluations after installation are available from Industrial Nucleonics, accurate data on "before and after" installation of AccuRay Systems can be compared. The following facts on product and process improvement are taken from these evaluation studies.

UNIFORMITY:

Average Profile improvement 43%

Average Machine direction variation improvement 47%

Improved uniformity of film further assures greater customer satisfaction and acceptance since problems occurring during slitting, wrapping, and sealing operations are significantly reduced... a consistently uniform film thickness also improves film printability.

YIELD:

Continuous, extremely accurate (to .00001 inch) scanning measurement and automatic control reduces tolerance spread. Target can be reduced while adhering to original tolerance limitations. Reduction of scrap production at startup and order changes also increases yield.

Average increase in yield with AccuRay System = 5%

Raw material savings on machine producing 150#/hour = \$15,750 year.

PRODUCTIVITY:

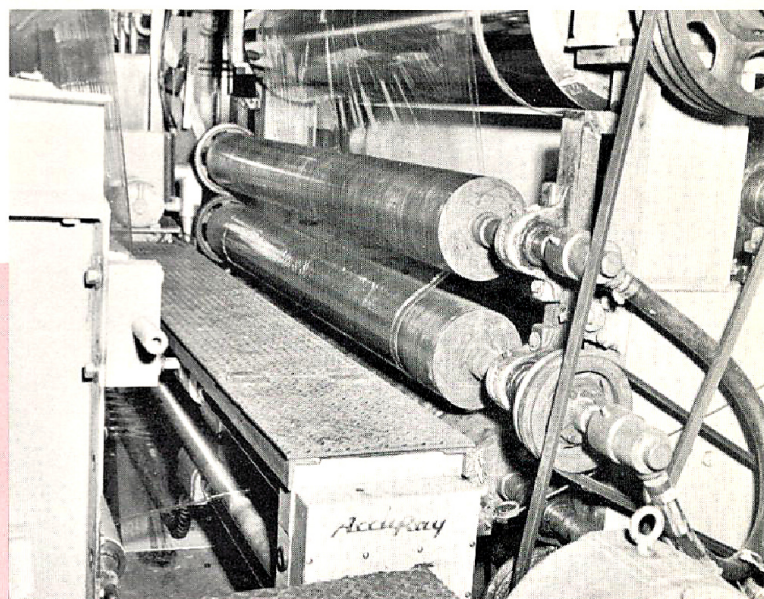
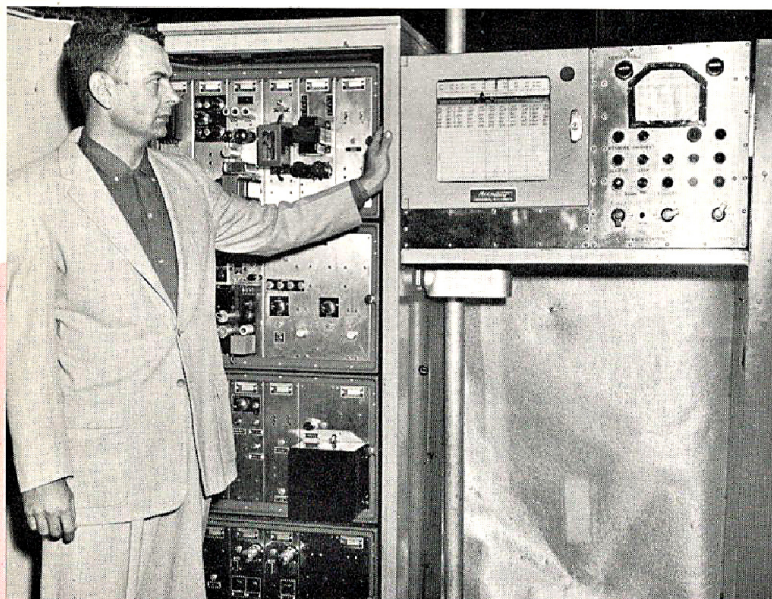
Since production rate is directly proportional to thickness variation, maintaining uniform thickness permits optimum extruder performance. Also, knowledge of sheet characteristics during "start ups" and "spec changes" enables the operator to get on specification faster, saving machine time and reducing scrap. Trouble shooting time is reduced because die adjustments, heating, and cooling malfunctions are quickly diagnosed.

Actual case studies show tangible savings...

Increased productivity amounting to 4 to 6% is obtained from higher throughputs, reduced scrap, faster startups, and spec changes. This increase amounts to 300 hours per year in additional production capacity per extruder.

Annual savings in Extruder Operating Costs \$7900.

Under Control Systems for Flat Die Extruded Film and Sheet



An AccuRay Series "E" System at Ludlow Paper Company, Homer, La., maintains close control of uniformity. Shown at the right is the scanning measuring unit. The operator's control and equipment cabinets are shown on the left.

time manufacture a HIGHER QUALITY PRODUCT

FLAT DIE EXTRUDED SHEET

With improvement in plastic materials and processing, the trend in Flat Die Sheet Extrusion is toward higher production rates and reduced sheet thickness. In this light, cross sheet and machine direction uniformity becomes of paramount importance in relating raw materials to yield — that is, maximum square footage of film per pound of raw material will result only if the control band is narrowed and sheet thickness maintained. The following data taken from actual evaluations demonstrate the economic benefits of AccuRay Measurement and Control Systems on Flat Die Sheet Extrusion.

UNIFORMITY:

Average Profile Improvement — 51%

Average Machine Direction Improvement — 48%

Other benefits to producers and users of AccuRay controlled flat die sheet are:

- ... Improved surface characteristics
- ... Fewer rejects in vacuum forming operations
- ... Assurance of providing customers with closer tolerance sheet

YIELD:

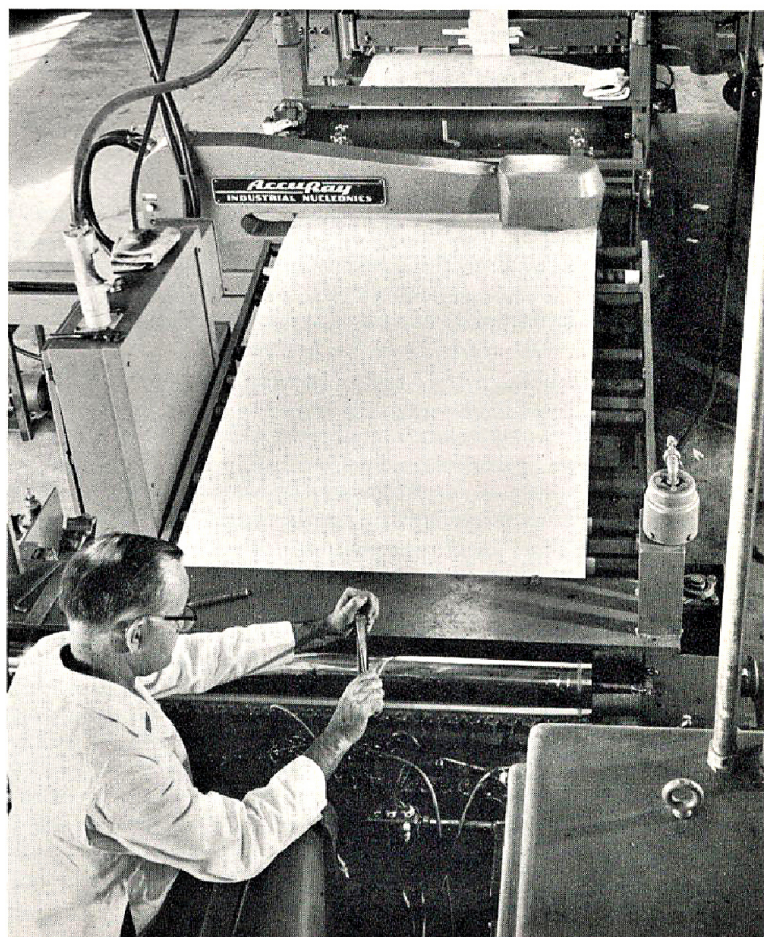
Average weight improvement for same specifications — 3%

Since the average extruder producing flat die sheet processes \$800,000 to 1½ million dollars per year of raw material, savings range from \$24,000 to \$45,000 per extruder.

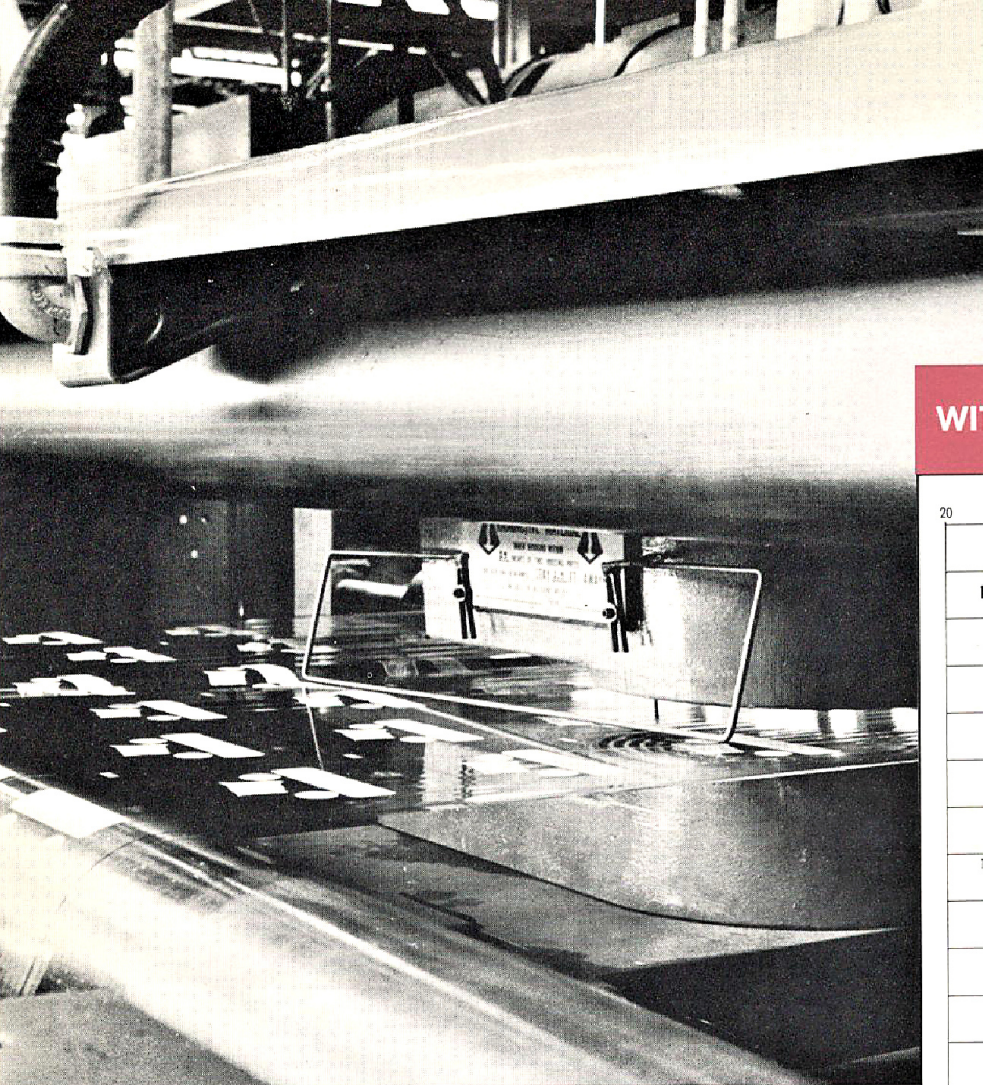
PRODUCTIVITY:

Throughput increased 5% to 12% per hour, or, based on a 400 lbs. per hour extruder, capacity is increased 120,000 lbs. of material per year.

Continuous scanning measurement enables the operator to obtain maximum extruder performances knowing that malfunctions will be revealed instantaneously.



At Gaylord Packaging Corporation, South Hackensack, N. J., the AccuRay System is controlling uniformity of extruded sheet.



An AccuRay Measuring Head scanning extruded polyethylene laminated film at Standard Packaging Corporation. Says Standard Packaging, "The AccuRay System helps to deliver a film microscopically even . . . no thin spots . . . no humps or buildups . . . consistently suited to high speed packaging."

AccuRay

Systems for Extrusion Coating

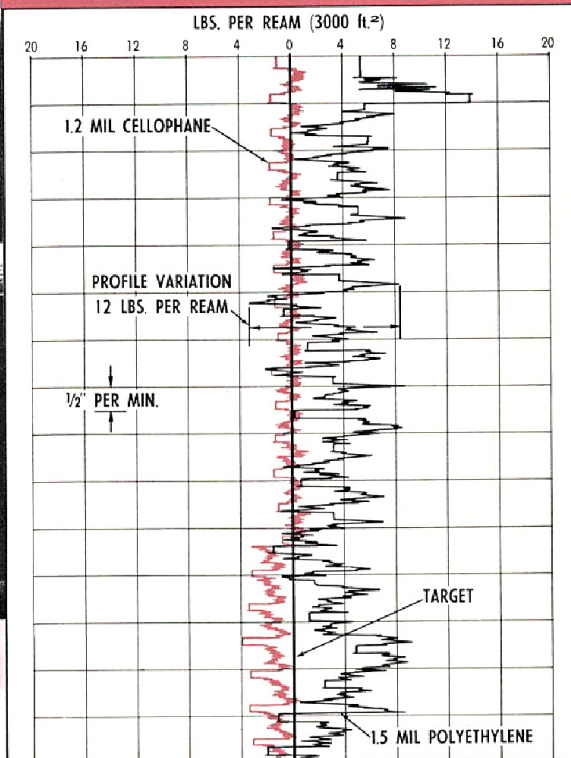
Conventional measurement techniques are ineffectual when applied to thin films and wide base sheets commonly used in polyethylene extrusion coating. Samples while difficult to obtain with destructive measurement techniques are representative of only a small fraction of the material being processed. Therefore, scrap costs soar due to excessive production of "off-spec" film.

Continuous, non-contacting, Dual AccuRay Systems are applied to extrusion-coating processes to overcome conventional handicaps. One AccuRay System measures the base sheet alone, and the other measures the combined thickness of substrate and polyethylene. By differential computation, a highly accurate and continuous measurement of polyethylene thickness is obtained. In scanning the entire sheet, AccuRay Systems also provide the invaluable service of detecting flaws caused by such random conditions as temperature fluctuations or carbon particles lodging along the die lip.

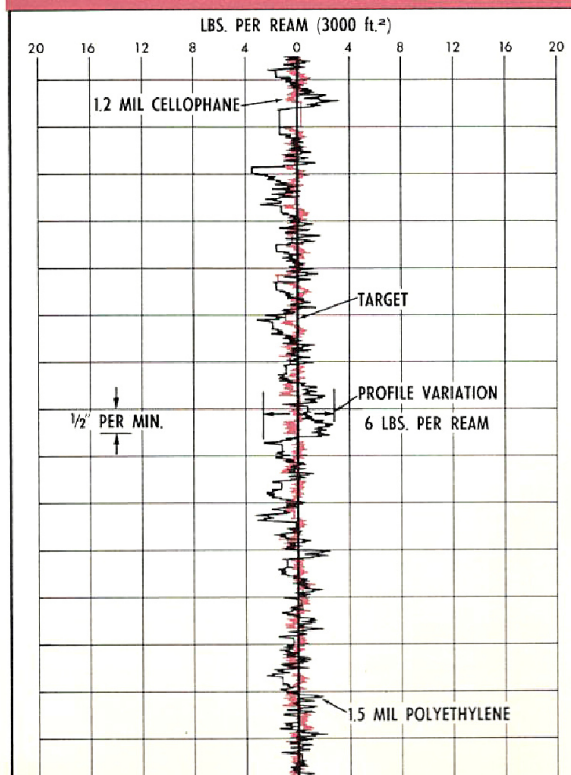
Extensive studies of two AccuRay applications in a polyethylene-on-cellophane process reveal the savings possible with assured control. The operation included coating 300 gauge cellophane with 2 mil polyethylene in one process, and with 1.5 mil polyethylene in the other. Before installing the AccuRay Systems, the manufacturer was applying film of greater than target thickness to insure adequate coating. Average thickness was reduced 0.08 mil after AccuRay measurements provided a continuous picture of film thickness characteristics. Annual polyethylene savings of \$23,620 resulted from closer control of the 2 mil process, while the 1.5 mil operations showed film savings of \$17,720/yr.

Savings due to scrap reduction, faster startups and spec changes, etc. brought total direct savings to \$72,180 per year.

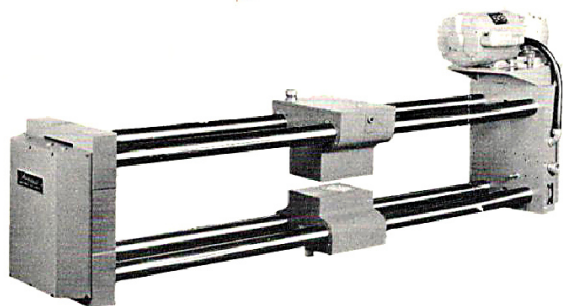
WITHOUT AccuRay CONTROL



WITH AccuRay CONTROL

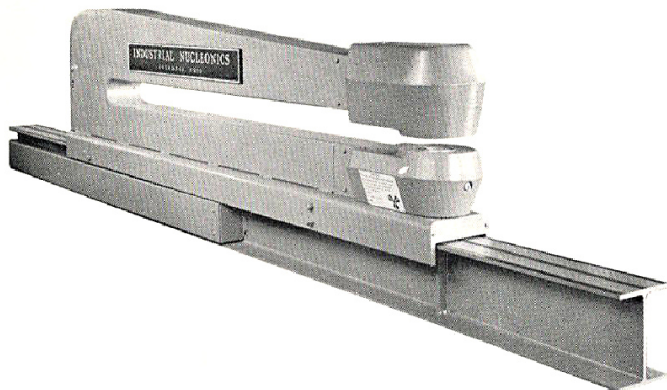


AccuRay Measuring Units Designed for All Extruders



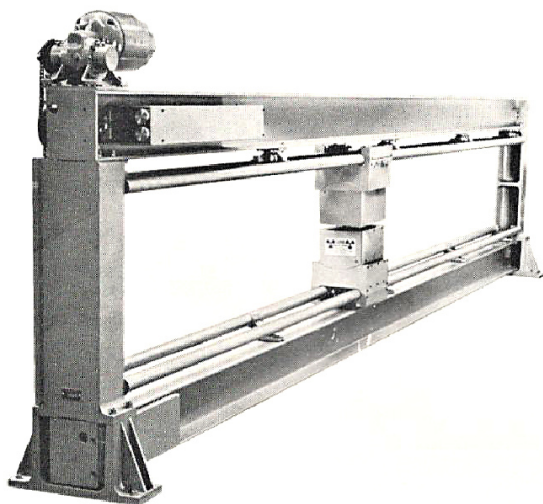
MINIATURE O-BRACKET

Design of the AccuRay Miniature O-Bracket source-detector unit emphasizes conservation of machine-direction line space and minimum off-machine space requirements. The unit is available for sheets up to 160" wide, and is applicable to horizontal, vertical, or angular passlines.



BASE MOUNTED U-BRACKET

The base mounted U-Bracket is designed primarily for applications where it is necessary to have considerable space on the extruder for threading and other operations. The unit requires less than 12 inches of machine-direction line space and is available for sheet widths up to 140".

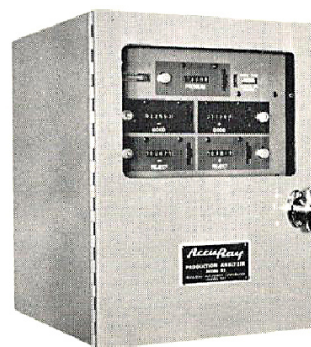


WIDE O-BRACKET

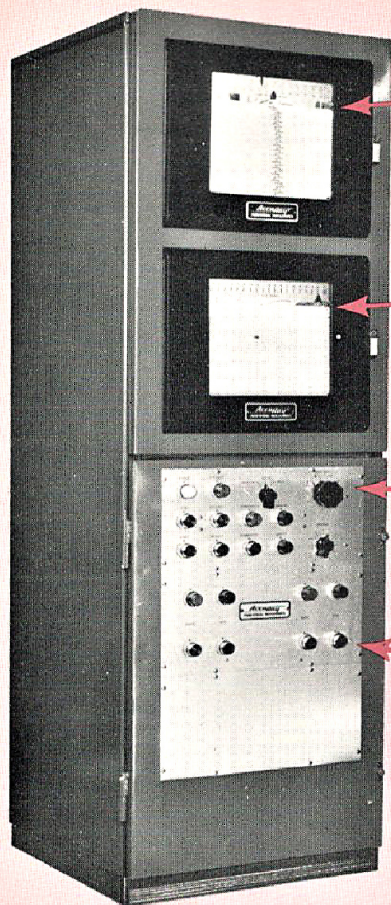
The AccuRay Wide O-Bracket is designed for sheets up to 300" wide. Vertical clearance of 22" between upper and lower traversing tubes facilitates high speed process operations such as threading, etc. The unit requires minimum machine-direction and off-sheet space and can be used with passlines up to 25° from horizontal.

PRODUCTION ANALYZER

The AccuRay Production Analyzer continuously divides total footage production into five weight or thickness classifications: (1) premium, (2) good (high), (3) good (low), (4) reject (high), and (5) reject (low). The cumulative amount of downtime is also presented by the Production Analyzer, reading in tenths of minutes. All counters have six digits.



AccuRay® Series "E" Construction



AVERAGE RECORDER

Presents Average Cross Sheet Thickness.

PROFILE RECORDER

Presents horizontal readout of weight variations across the sheet.

GAUGE CONTROL PANEL

Measurement, presentation, standardization, and positioning controls.

AUTOMATIC CONTROL PANEL

Provides for selection of automatic or manual control of the process.

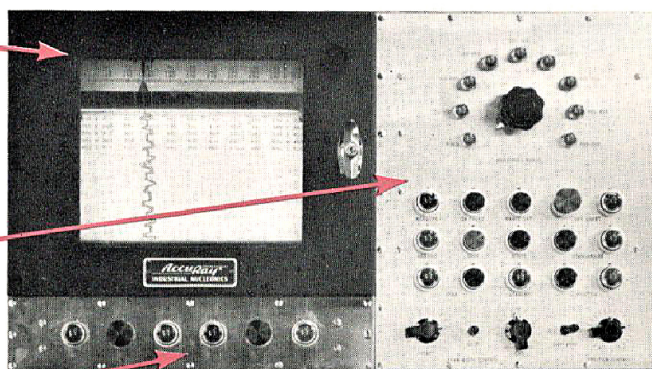
OPERATOR'S STATIONS

AVERAGE PROFILE RECORDER

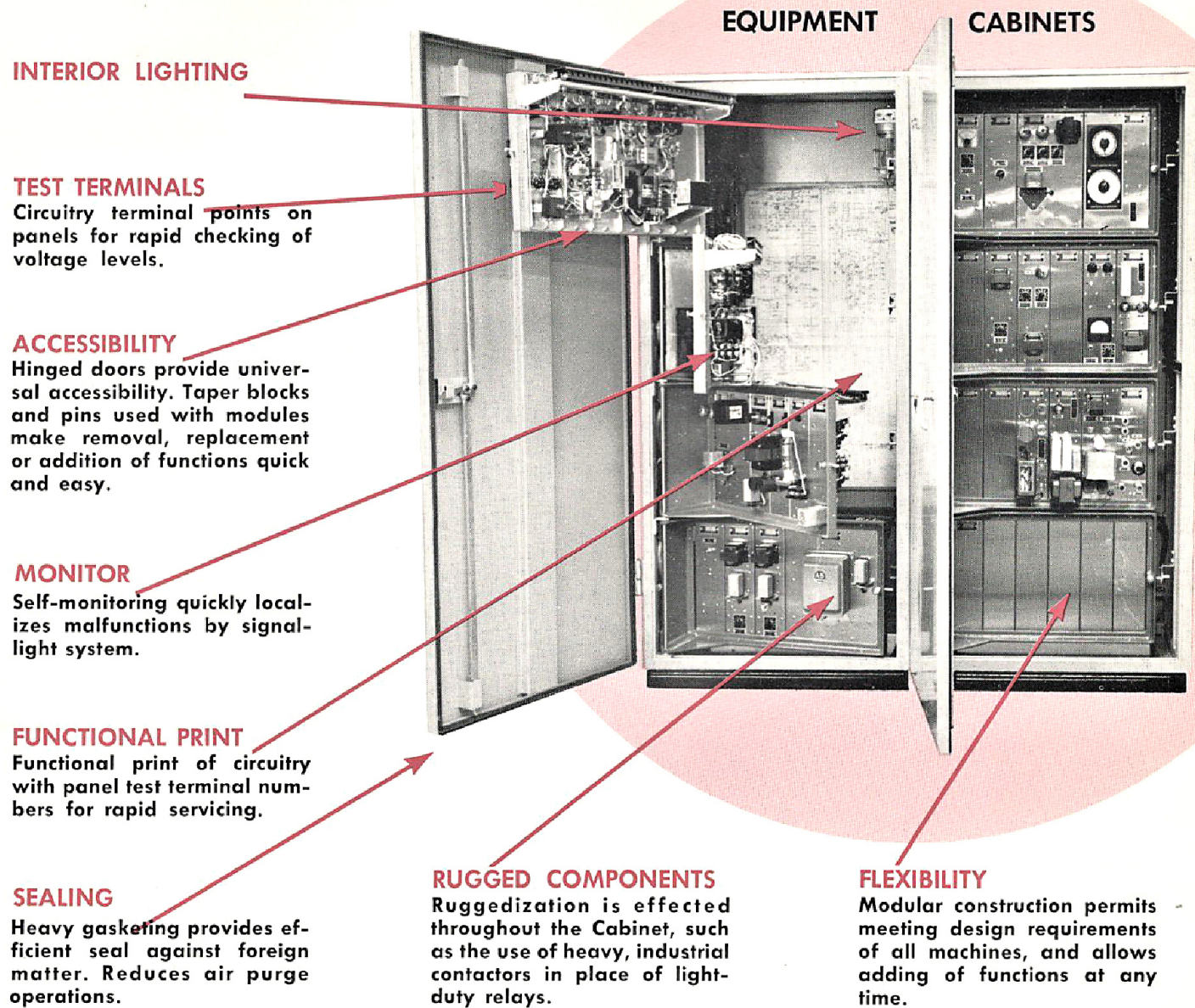
Presents both profile and average cross sheet thickness. Also presents machine direction variations.

GAUGE CONTROL PANEL

AUTOMATIC CONTROL PANEL



...Designed for Industrial Environments



The high levels of accuracy and reliability presented by AccuRay Extruder Measurement and Control Systems are largely due to the advanced design of AccuRay Series "E" equipment. Series "E" electronics incorporate ruggedness of construction, ease of operation and ready accessibility of all components. Lighted interiors, cabinet ventilating, an internal telephone system and locking doors are included as part of the AccuRay convenience. Salient features of Series "E" electronic equipment bays and operator's stations are shown with the photographs on these pages.

VERSATILITY

Flexible design of Series 'E' provides for compatibility with present and future instrumentation and data handling systems, assuring minimum modifications as process controls and data handling are expanded. Additional functions may frequently be added to the system without affecting operations.

AUTOMATIC STANDARDIZATION

Patented* System covering the method and means of standardization obtained by automatically and periodically moving the gauging system off-sheet and correcting for both internal and external conditions. Assures accurate and reliable measurements. (*U.S. Patent No. 2,829,268)