RÉSUMÉ

APPLICATIONS DE LA COMMANDE HYDRAULIQUE ET PNEUMATIQUE DANS L'INDUSTRIE DE FABRICATION DE CÂBLES ET DE FILS ÉLECTRIQUES

Jim Sinki

Ce rapport traite de l'application de la commande hydraulique et pneumatique à trois procédés de l'industrie de fabrication de câbles et de fils électriques, soit le préchauffage des lingots, le bobinage des câbles, et le transport des granules de matière plastique.

Le rapport compare également les systèmes de commande électrique, mécanique, hydraulique et pneumatique et indique des applications où l'utilisation combinée de ces systèmes pourrait se révéler avantageuse.

ACKNOWLEDGEMENT

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CHAPTER I

INTRODUCTION

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INTRODUCTION

Fluid control systems can, in many applications, offer higher reliability, lower cost, and greater environmental tolerance than their mechanical or electrical counterparts. This is due largely to their simplicity of design, which results in comparatively low manufacturing costs, low maintenance requirement, and ready adaptation to many existing industrial processes.

Fluid control is the technology of employing general fluid phenomena to perform the three main functions of sensing, logic and control, and actuation. Within the field of fluid control, there are two sub-groups - pneumatic and hydraulic. In situations where a pure fluid control system could not function satisfactorily (generally where a high degree of sensitivity to low signals and/or a speedy response is required), electrical and fluid control systems often complement each other.

In an industrial application, the customer usually has little or no preference for any given control system - his major criteria being: low initial cost, economy of operation, ease of maintenance, and high reliability. To meet these criteria, a combination of mechanical, electrical, and fluid systems is often the indicated approach.

It is the object of this report to describe and evaluate three of these combined systems (electrical/mechanical/fluid) which have performed well in the Wire and Cable manufacturing industry.

This report is organized as follows:

Chapter II - "Air Jet Damper": this maintains a positive pressure inside the heating chamber of the continuous furnace, in order to prevent infiltration of outside air, and hence, the oxidation of the heated copper ingots. The sensing device uses a diaphragm valve, actuation is being performed by a lever, and control by a pneumatically-operated butterfly valve.

Chapter III - "Venturi Conveying System": this unit conveys plastic pellets from their container to the hopper of a plastic extruding line. Sensing is accomplished by two electro-mechanical limit switches, actuation is by a flow of air through a venturi tube, and control is by an electro-mechanical solenoid valve.

Chapter IV - "Hydraulic Traversing System": this mechanism is required on wire and cable bobbin winding machines in order to distribute wire or cable in a uniform cylindrical manner during the winding operation. Sensing functions are performed by two electro-mechanical limit switches, actuation is by a hydraulic cylinder, and control is by means of a 4-way, solenoid-actuated valve.

Chapter V - "Concluding Remarks": a summary of the advantages of fluid control systems combined with electrical and/or mechanical controls over conventional systems.

Appendices A, B, C, D and E illustrate different winding techniques which are applied in the Wire and Cable manufacturing industry, such as electrical, mechanical, hydraulic and magnetic.

Appendices F, G and H show other advanced mechanical and pneumatic traversing techniques.

CHAPTER II

AIR JET DAMPER

CHAPTER II

AIR JET DAMPER

2.1 FURNACE REQUIREMENT IN THE WIRE AND CABLE MANUFACTURING INDUSTRY

Two types of furnace are used in Wire manufacturing:

1. A continuous furnace - for the rod mill process.
2. A bell type furnace - for the annealing process.

The continuous furnace is described in further detail below to show the use of the air jet damper whose function is to maintain a positive furnace pressure.

2.1.1 Continuous Furnace

This furnace is an integral part of the rod mill. It is used to preheat copper ingots for the subsequent rolling process. The ingot enters the heating chamber at (A) (figure 1) and move progressively through the furnace by means of a mechanical pusher (B) to the discharge location (C). The temperature of the furnace varies from one section to another, but does not change with time. The material goes through its heating cycle by moving continuously from the cold end (A) of the furnace to the hot end (C). The heated ingots must be free from oxide inclusions, i.e. must be protected against even a slight drop in pressure below atmosphere in the heating chamber of the furnace which would suck in cold air from the surrounding atmosphere, cooling the ingots and increasing oxidation. To control the infiltration

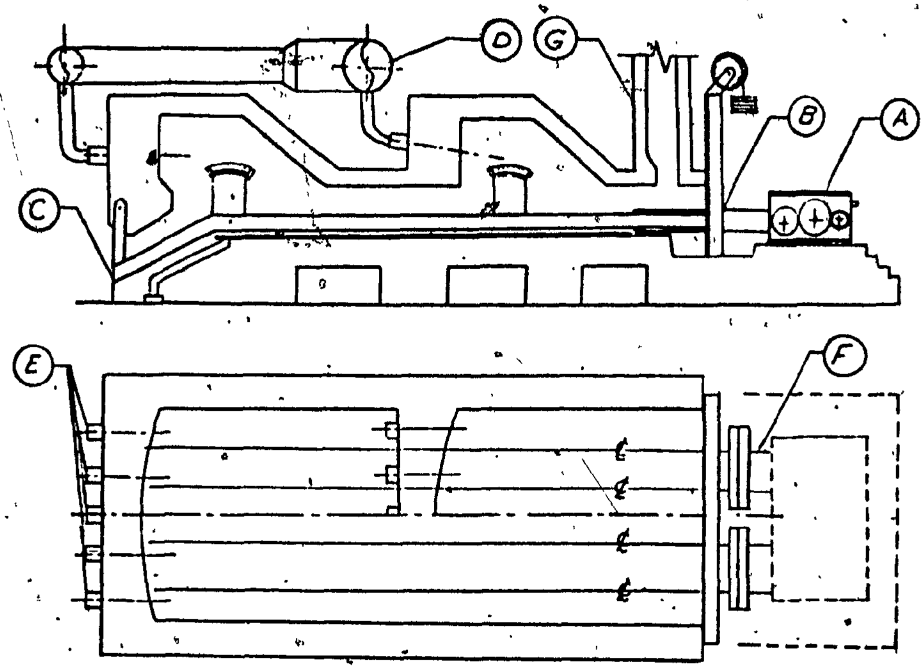


FIG. 1 CONTINUOUS FURNACE
Reference 1

A Ingot inlet (cold-end)
B Mechanical pusher
C Discharge location (hot-end)
D Combustion air supply line
E Burners
F Copper ingots

of cold air, the furnace pressure must be kept lightly above atmospheric, usually 0.025" of water column (0.001 lb per in^2). A control system is necessary to maintain this pressure in the furnace. In the two following sections, the conventional control mechanism and the air jet damper are outlined and compared.

2.2 CONVENTIONAL METHOD OF PRESSURE CONTROL OF CONTINUOUS FURNACES

Figure 2 shows a butterfly valve commonly used to control exhaust gases at elevated temperatures. The frame of the valve (1) is made of castable material (2), reinforced by stainless steel wire mesh (3). Both the construction and on-site installation of this type of damper must be performed with precision if gas leakages are to be kept to a minimum. The material from which the damper is made should be selected with care to avoid problems arising from cracking or wasping in operation, while the damper itself (4) should have a close slide fit on the machined working face of the inclined frame (1). The most common problems encountered with this type of damper are: inefficient use of fuel caused by maladjustment of the valve and seat; gas leakage resulting from imprecise fabrication or from faulty installation and spalling and dislodgement of brickwork caused by a combination of high temperatures and frequent valve actuation.

A variety of automatic power actuators can be used with this valve, among them being positioning relays and diaphragms (figure 2b shows a diaphragm actuator).

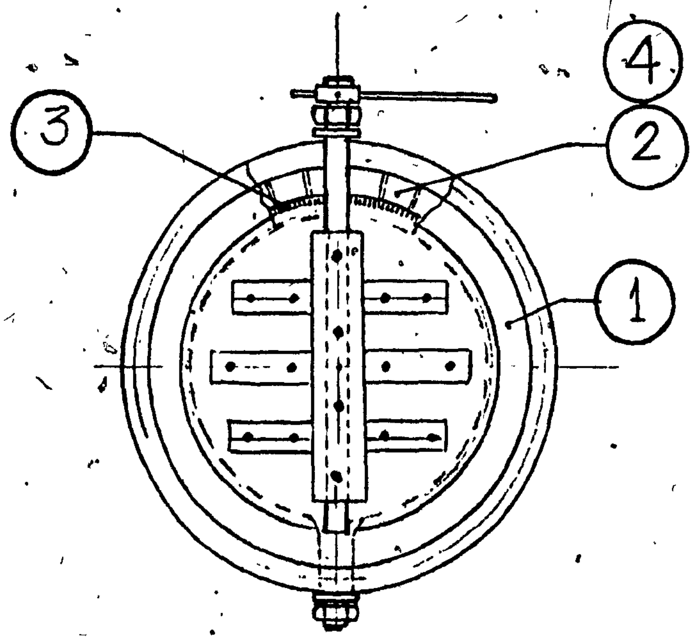


FIG. 2a CONVENTIONAL MECHANICAL DAMPER
(Butterfly valve)
Reference 2

1 Frame
2 Castable material
3 Stainless steel mesh
4 Damper disk

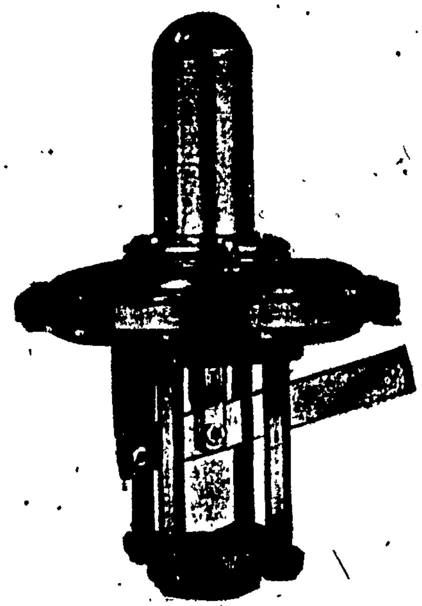


FIG. 2b "DIAPHRAGM TYPE" DAMPER ACTUATOR
Reference 2

The selection of the actuator is determined by the type and degree of control desired, the power source available, torque required and the type of control system to be utilized.

2.3 AIR JET DAMPER

2.3.1 System Description

Figure 3 shows a cross-section along a continuous furnace and chimney at the exhaust end. The ingot is pushed on to the hearth level by a mechanical pusher (not shown). A set of high velocity air nozzles are installed on the periphery of the furnace flue. They are fed through a manifold ring which is installed on the flue throat (see figure 4). The control is so designed that, as soon as furnace pressure drops below that of the atmosphere, the stream of air from the nozzles will be injected directly into the flue throat. This stream of air forms a curtain which restricts the furnace draught, and consequently restores the furnace pressure to a level slightly above atmospheric. Orifices are fixed at a selected angle to maximize furnace pressure. Depending on its size, the manifold is fed by either a main combustion air blower, or by a separate blower. The volume of air required through the air nozzles is pneumatically controlled by a butterfly valve.

2.3.2 Principle of Operation

A differential pressure transducer is directly connected to the furnace hearth to measure the pressure differential between the furnace and the atmosphere. When furnace pressure drops below that of the surrounding atmosphere, the sensed air pressure exerts an unbalanced force on the diaphragm signal unit of the differential pressure transducer, which actuates an internal relay lever by means of two tension springs attached to the diaphragm.

A steady flow of air, regulated to 0.5 lb per in^2 passes through the air-operated control relay to the butterfly valve. The air pressure to the butterfly valve (and consequently the air flow to the jet damper), is proportional to the pressure difference sensed by the differential pressure transducer.

2.3.3 System Components and Selection

The following section describes the different components of air jet damper.

a) Air Nozzles (item 10, Fig. 3)

Four inch long nozzles are cut from schedule 80 pipe. Pipe diameter varies from 0.1875" to 0.5625" - to suit a range of flow from 1,100 CFH to 10,000 CFH per foot length of the air supply line. Jet holes are drilled directly in the flue, the centers being spaced 2" apart, and the holes being depressed 40^{o} from the cross-section of the flue. The nozzles are then positioned on the flue stack and are welded in place.

b) Manifold Ring (item 11, Fig. 3)

In the circular flue, a manifold ring having an inside diameter 10 to 11 inches greater than the outside diameter of the flue is desirable. Figure 4 shows a practical construction drawing for nozzle and manifold ring installation on a typical flue.

c) Air Blower (item 9, Fig. 3)

If the air damper is fed by a separate blower, it should be sized to provide adequate pressure and flow rate to both the burner and the damper at all firing rates. (As air for combustion is throttled to low fire, the damper requires more air to maintain furnace pressure. As burners are driven to a high firing rate, the damper requires less combustion air.) More detail on manifold sizing and air requirement calculations are given in special bulletins from North American Manufacturing Company. (Reference 6)

d) Diaphragm Operated Butterfly Valve (item 2, Fig. 3)

This valve is pneumatically operated and controls air flow to the air nozzles. It receives its signal from the furnace differential pressure transducer through the diaphragm operator supply line.

e) Pressure Sensing and Compensating Lines (items 8, 7, Fig. 3)

A pressure sensing line connects the furnace hearth to the furnace pressure transducer. Compensating line is required to compensate for the pressure loss across the pressure line. One end of the compensating line is kept free to the atmosphere, and the other end is connected to the opposite side of the pressure transducer.

f) Differential Pressure Transducer (item 6, Fig. 3)

This consists of an air-operated control relay and diaphragm operator. Figure 5 shows the different parts of the transducer. The differential pressure which is sensed by the sensing line causes an unbalanced force on the diaphragm operator. This force is then transmitted to an attached tension spring (item 15, Fig. 5b), which actuates an internal relay (item 5, Fig. 5a) lever.

g) Pressure Regulator (item 1, Fig. 3)

The purpose of the pressure regulator is to regulate the pressure of the incoming air flow to the pressure transducer. The opening or closing of the valve ensures a constant pressure designed to permit the smooth operation of the control relay. (See Figure 6)

h) Air Filter (item 3, Fig. 3)

The filter is used to protect the pressure control system from corrosive moisture, emulsified oil, and solid particles which may be found in the air line. It provides two stages of separation - cyclonic separation of the larger particles, and micronic edge filtration to remove the finer particles. Figure 7 shows the construction of a typical air filter. Solids and liquids are trapped in a large quiet zone at the bottom of the bowl (3), which has a drain cock (5). As air enters the bowl, a deflector plate (1) imparts

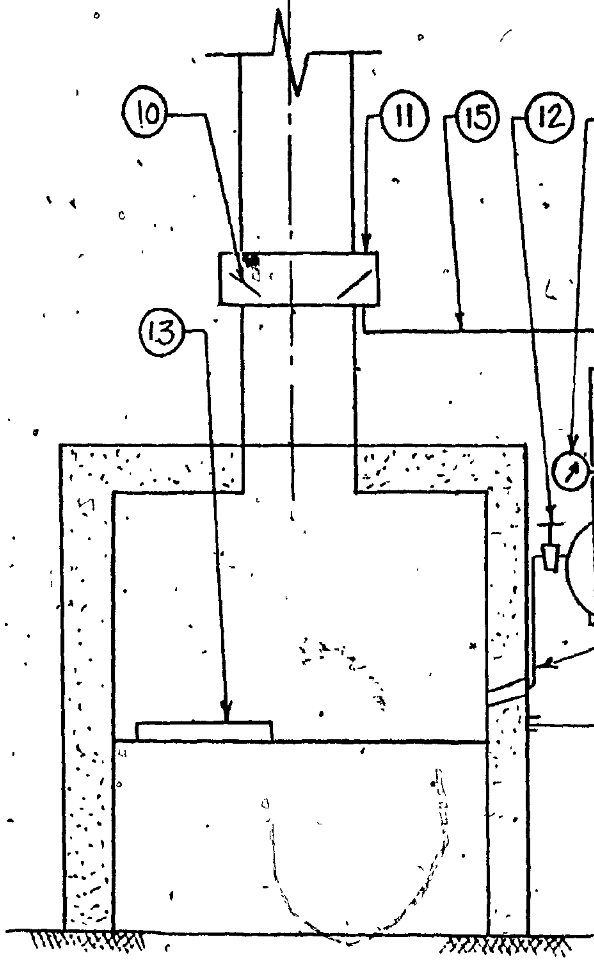
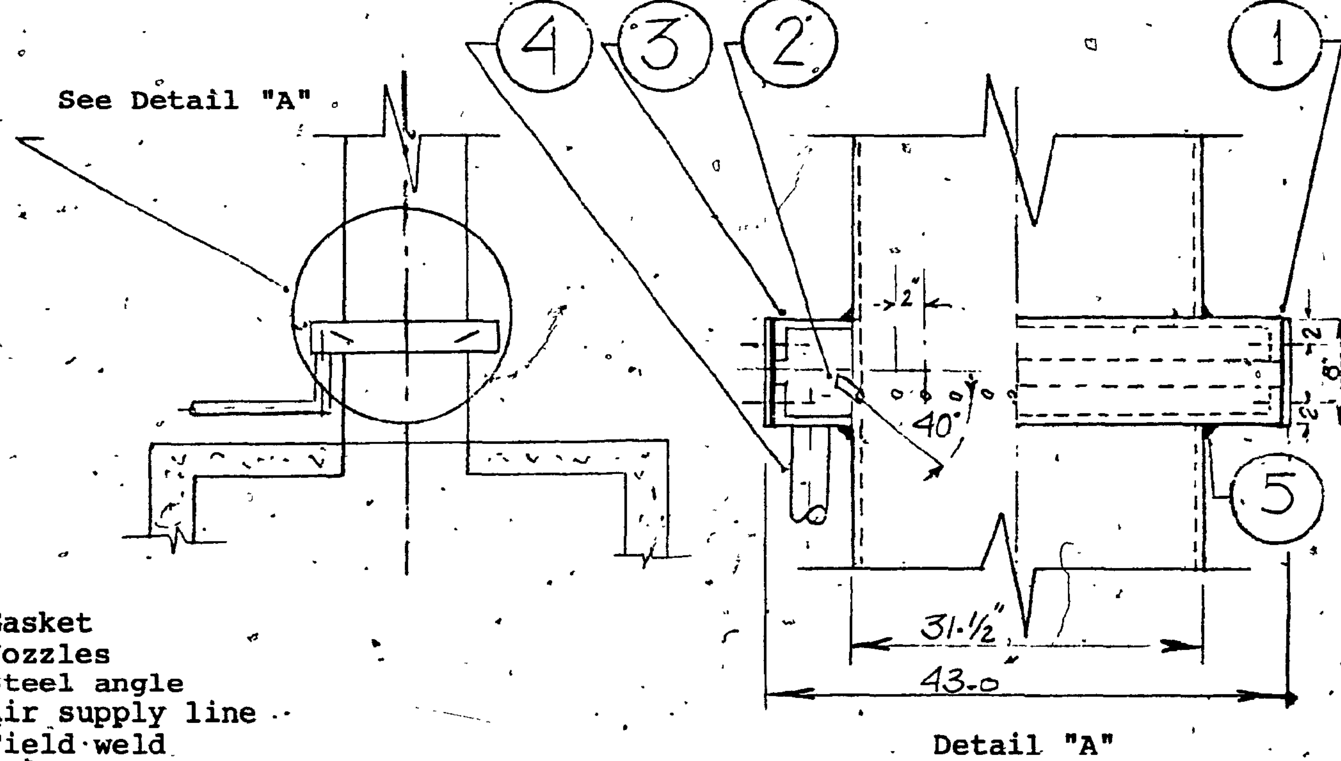


FIG. 3 CROSS SECTION ALONG A CONTINUOUS FURNACE NEAR THE COLD-END SHOWING A SCHEMATIC DIAGRAM OF THE AIR JET PRESSURE CONTROL SYSTEM
Reference 3

1	Pressure regulator	8	Pressure sensing line
2	Diaphragm operated butterfly valve	9	Damper air blower
3	Air filter	10	Air nozzles
4	Atomizing and pilot air line	11	Manifold ring
5	Pressure gauge	12	Gate valve
6	Differential pressure transducer	13	Ingots at hearth level
7	Compensating line	14	Pressure signal line
		15	Air supply line



1 Gasket
2 Nozzles
3 Steel angle
4 Air supply line
5 Field weld

FIG. 4 DETAILED DRAWING, SHOWING TYPICAL INSTALLATION OF AIR NOZZLES AND MANIFOLD RING ON A CONTINUOUS FURNACE
Reference 4

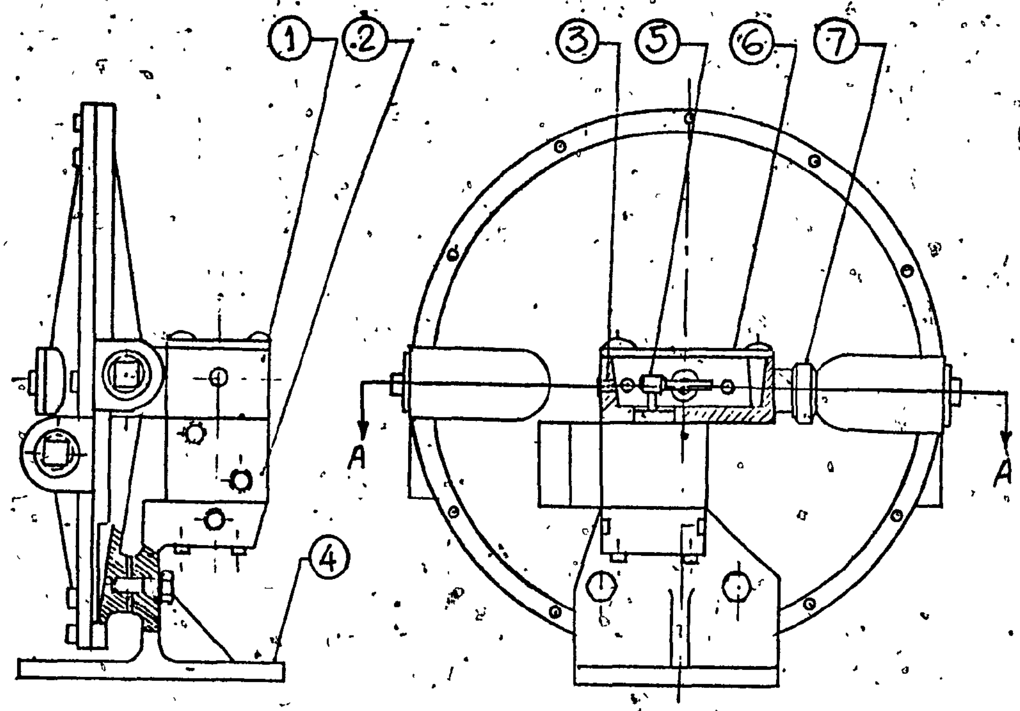


FIG. 5a DIFFERENTIAL PRESSURE TRANSDUCER
Reference 5

1 Adapter housing
2 Relay assembly
3 Knockout plug
4 Mounting base
5 Operating lever
6 Cover plate
7 Roll pin

NOTE: See FIG. 5b for details of section "A.A."

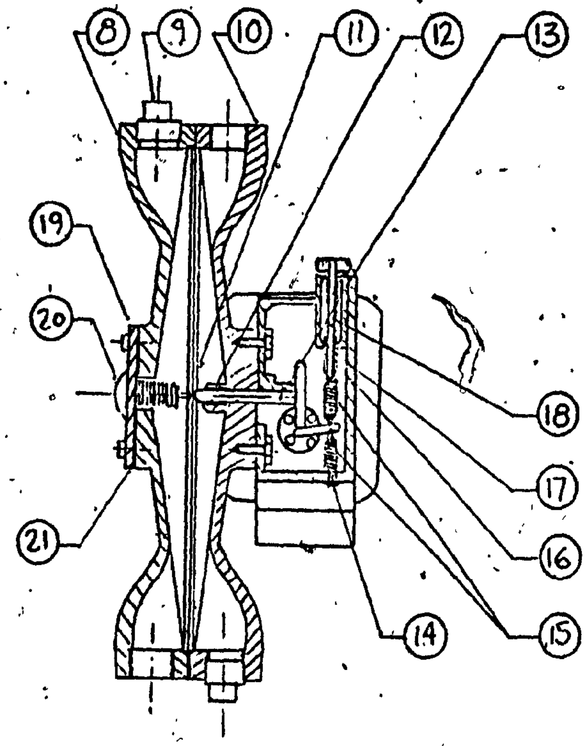


FIG. 5b DIFFERENTIAL PRESSURE TRANSDUCER
(Detail of section "A.A.")
Reference 5

8	Outer diaphragm shell
9	Square HD pipe plug
10	Inner shell diaphragm
11	Diaphragm assembly
12	Outer seal bushing
13	Transmission pin assembly
14	Spring anchor pin
15	Tension springs
16	Spring adj. slide assembly
17	Spring adj. slide key
18	Spring adj. screw assembly
19	Bias spring plate
20	Bias spring
21	Cover plate gasket

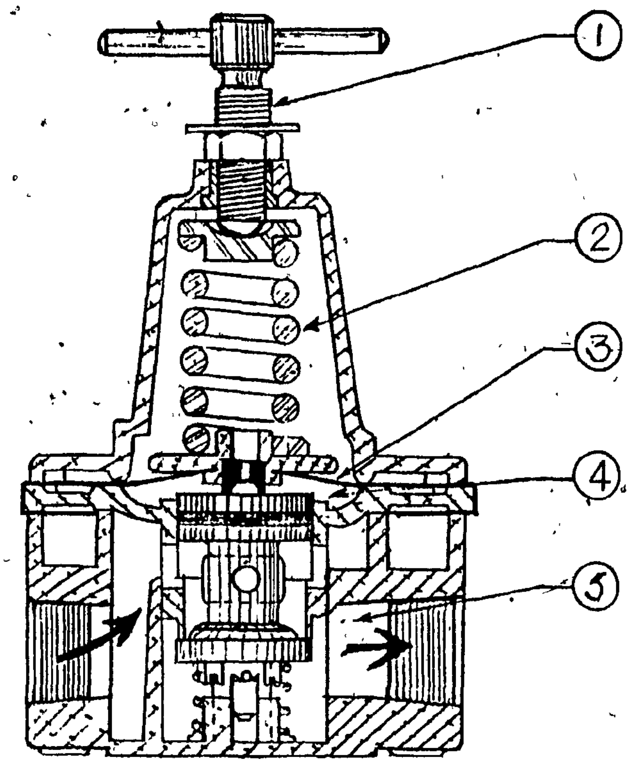


FIG. 6 PRESSURE REGULATOR

1 Square head adjusting screw
2 Spring
3 Diaphragm
4 Diaphragm chambre
5 Downstream side of the valve

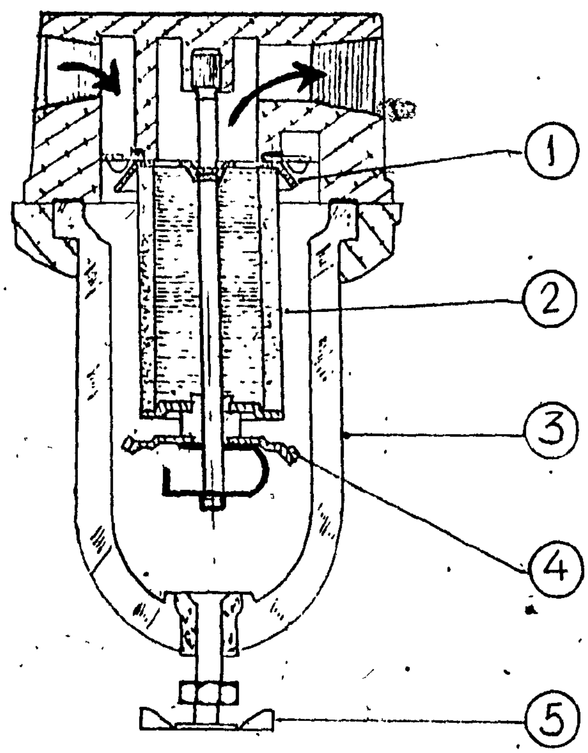


FIG. 7 AIR FILTER

1 Upper deflector plate
2 Ribbon type plastic impregnated element
3 Bowl
4 Lower baffle plate
5 Drain cock

a whirling action. The resulting centrifugal effect causes the larger solid particles and the free liquid in the line to be thrown to the side of the bowl. A lower baffle plate (4) reverses the flow of air to meet that induced by the deflector plate, thus providing a quiet zone into which the separated solids and liquids will settle. These will not subsequently re-enter the air stream. After cyclonic separation, the air is passed through a standard ribbon-type, plastic impregnated elements (2) which filters remaining particulates down to a uniform 40 microns (approx. 0.00015").

i) Pressure Gauge

The gauge indicates the set-up pressure of the air flow passing through the pressure transducer and is regulated by the pressure regulator.

j) Vacuum Gauge

The vacuum gauge simplifies the setting of the furnace pressure control system at the desired pressure. The gauge is connected to an extra tap on the furnace pressure side of the pressure transducer. The relay spring can then be adjusted manually to change furnace pressure to the desired level.

k) Solenoid Valve

The solenoid valve is used to prevent the flow of air from the air jet damper down the flue into the furnace when the furnace door is open. It is installed at the air supply line to the butterfly valve, and is connected to a limit switch at the furnace door. Every time the door opens, it actuates the limit switch and hence the solenoid valve, restricting air flow to the air jet damper.

For selection criteria for system components, refer to North American Manufacturing Company bulletins (reference 6).

2.3.4 Pressure Range and System Sensitivity

By informed selection of system components coupled with correct installation, a furnace pressure from 0.01" wc to 1.0" wc above atmospheric can be attained. System sensitivity is 0.0075" wc (0.00027 lb per in^2).

2.4 CONCLUSION

Although the cost of air jet damper components and system is slightly higher than that of a standard conventional mechanical damper, the air jet damper meets at least three of industry's far major criteria - high reliability, economy of operation and ease of maintenance.

CHAPTER III

VENTURI APPLICATION IN CONVEYING SYSTEM

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VENTURI APPLICATION IN CONVEYING SYSTEM

3.1 REQUIREMENT OF PNEUMATIC CONVEYING SYSTEM IN WIRE AND CABLE MANUFACTURING INDUSTRY

Insulating materials are applied to electric cable to prevent leakage of current and, when used in with high voltage application, they must also be able to resist dielectric puncture. An extrusion process is employed to apply the rubber and plastic insulators (see figure 8). In this process, the material is fed into the feeding hopper (4) of an extrusion machine and then is forced to flow rapidly through a barrel (7) by means of a rotating screw (5) to the discharge end (8). Extruded material then surrounds the bare wire or conductors which move at a steady speed forming a right angle to the machine center line. Screw extrusion of plastic or rubber requires closely controlled heating of the barrel by means of electric heating elements (6).

Rubber (usually in ribbon form) is conveyed to the extruder's feed end opening by means of an automatic mechanical feeder, while plastic material which is usually in form of pellets, is conveyed to the extruder's opening through a hopper, by means of pneumatic conveyors or vacuum pumps.

In the following sections, two systems of conveying plastic material are outlined.

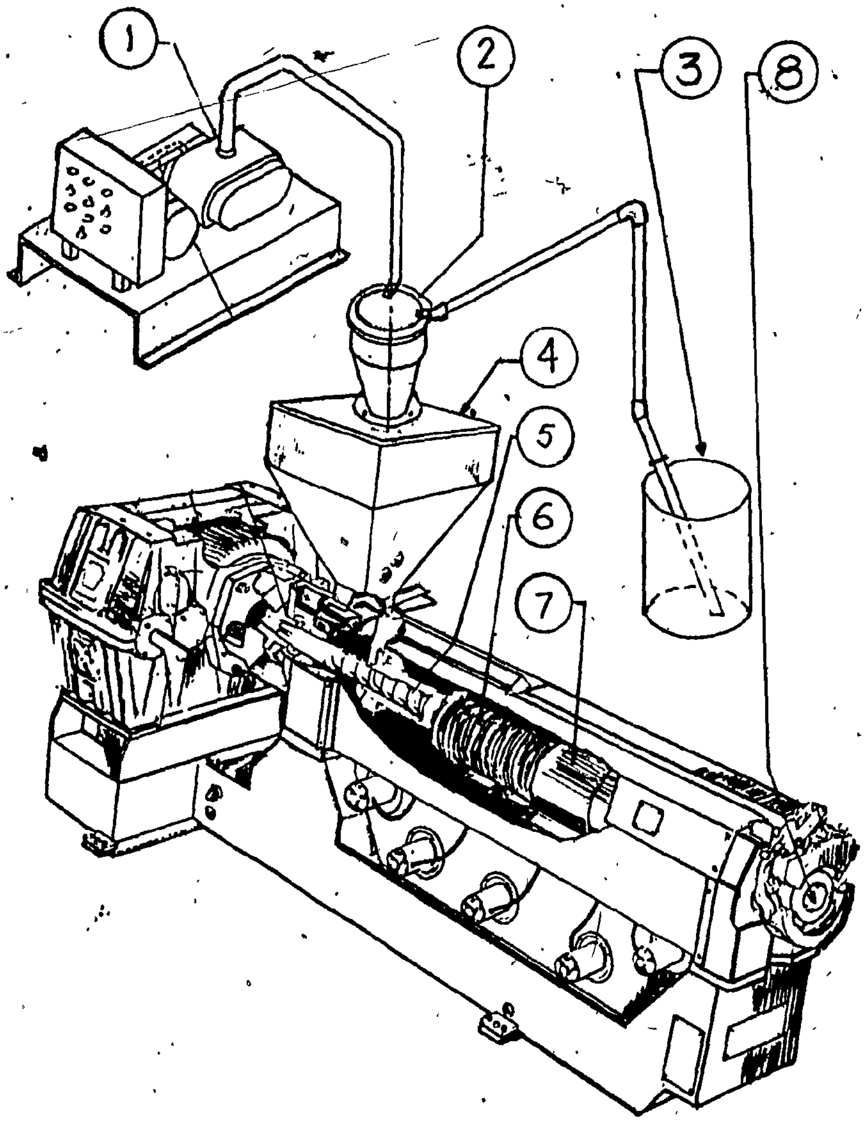

FIG. 8 POSITIVE DISPLACEMENT VACUUM PUMP INSTALLED ON PLASTIC EXTRUDING LINE
References 7, 8

1 Vacuum pump
2 Vacuum chamber
3 Plastic container
4 Hopper
5 Screw
6 Heating elements
7 Barrel
8 Discharge end

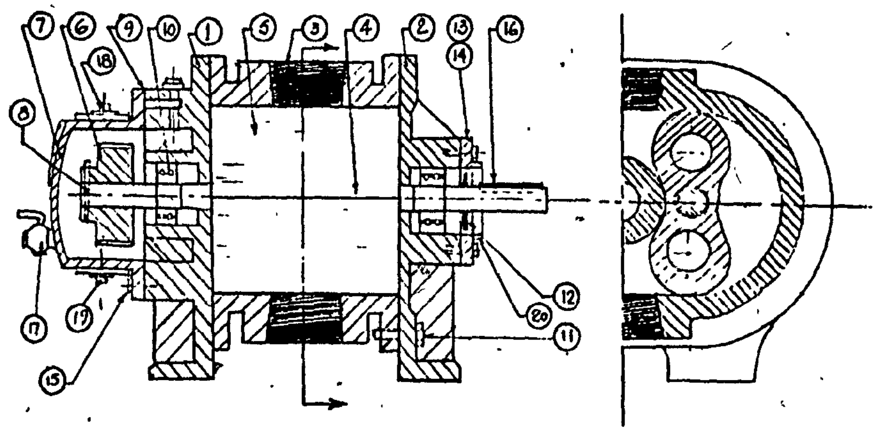

FIG. 9a SECTION ACROSS A POSITIVE DISPLACEMENT VACUUM PUMP SHOWING ITS DIFFERENT PARTS

1	Head plate (gear end)
2	Head plate (drive end)
3	Cylinder
4	Driving shaft and impeller
5	Driven shaft and impeller
6	Timing gears (1 pair)
7	Gear house
8	Gear pins
9	Gear house gasket
10	Seal bearings
11	Head plate cap screws
12	Oil retainer (end cover)
13	End cover (drive)
14	End cover (blind)
15	Gear house cap screws
16	Pulley key
17	Oil level cock
18	Oil filler plug
19	Oil drain plug
20	End cover cap screws

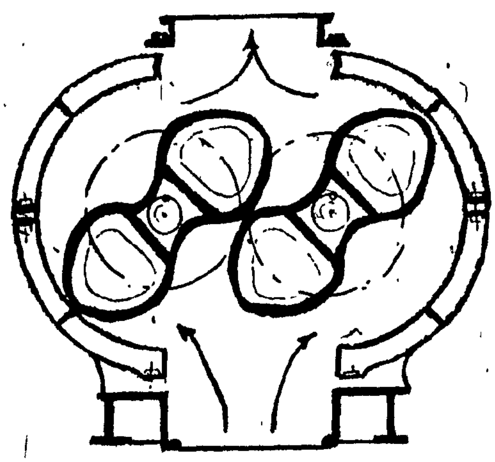

FIG. 9b SECTION ACROSS THE IMPELLERS
SHOWING PATHS OF TIMING GEARS

3.2 CONVEYING SYSTEM OF PLASTIC MATERIAL

The operating principle of the plastic pellet conveying system is based on producing a negative pressure inside a pick-up tube which is inserted in the material container. This negative pressure sucks up material and transports it to the discharge hopper. Two alternate methods being used in the Wire and Cable manufacturing industry to produce this negative pressure:

1. Positive displacement vacuum pump.
2. Venturi tube.

3.2.1 Conveying By Means of Vacuum Pump

This system is designed to automatically load the extruding machine, directly from the material container. Negative pressure is produced in a cyclonic vacuum chamber. This chamber's prime function is to protect the vacuum pump. It does this by acting as a buffer between the feed hopper and the pump itself - receiving pellets through the pick-up tube for distribution to the extruding hopper while preventing aspiration of plastic pellets by the pump.

a) Vacuum Pump

Figure 9 shows a positive displacement vacuum pump. It consists of two impellers mounted on parallel shafts, which rotate in opposite directions within the pump casing. As they rotate, air is drawn into the space between the impeller and the casing. As the impeller continues to turn, it opens to the discharge and pushes the trapped air through an outlet to the atmosphere, causing a positive movement of the air. This action is repeated twice for each revolution of each impeller, or four times for each turn of the shaft. Within the normal rated speeds, this results in a practically steady air flow, with little objectionable pulsation or surging. The pump is connected via a flexible hose to a vacuum chamber. Vacuum pumps are available with either single or dual pumping stations. A dual station is highly desirable when an air drying process is required prior to the extrusion process. In this case, the first station will convey material from the container to the input of an air dryer, and the second station from the output of the dryer to the extruding hopper. Figure 10 shows typical characteristics of vacuum pump used to convey plastic pellets.

b) Vacuum Chamber

The vacuum chamber is both a material receiver and a means of preventing the flow of plastic material to the vacuum pump. It is mounted on top of the extruding hopper. It is equipped with two mounting flanges, one being connected to the suction side of the vacuum pump, and the other to the pick-up conveying tube. The free end of the pick-up tube is inserted in to the material container (see figure 10).

The vacuum chamber is also equipped with a cartridge filter to remove the finer particles contained in the dusty types of material from the air exhaust system.

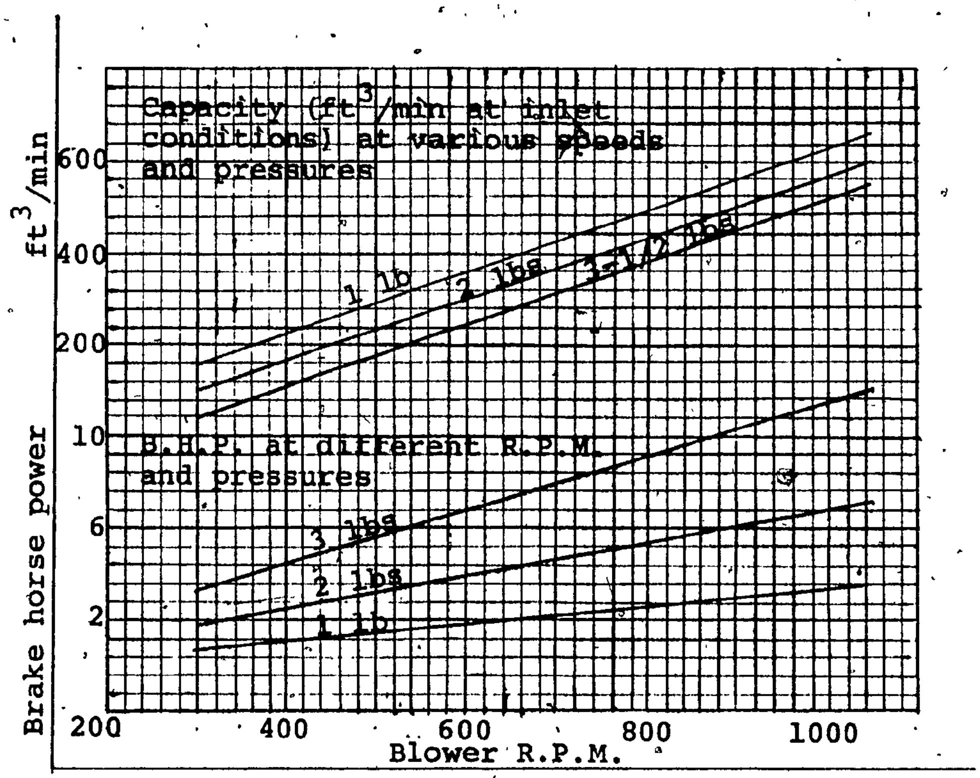

FIG. 10 CHARACTERISTICS (CAPACITY IN CU FT OF AIR PER MINUTE AND B.H.P. AT DIFFERENT R.P.M.) OF A TYPICAL POSITIVE DISPLACEMENT VACUUM PUMP USED TO CONVEY PLASTIC PELLETS

The vacuum chamber discharges the pellets directly into the extruding hopper through an aluminum flapper valve. The loading control is accomplished by means of a timer, solenoid valve, and two limit switches, all contained in a control box.

c) Air Dryer

In general, moisture is considered to be a processing problem in the plastic industry. In the Wire and Cable manufacturing industry, absorbed moisture reduces cable insulation resistance.

Some plastic material acts as a sponge, gathering internal moisture and must be dried before further processing. Drying is accomplished by blowing dry air through the material, forcing the water vapor contained inside the pellets to seek the point of equilibrium with the surrounding air. Plastic used for wire insulation is normally of a non-hygroscopic nature - absorbing moisture only on its surface area. With this type of material, drying is accomplished by blowing hot air over its surface. In this application, the plastic pellets must be dried for a minimum of two hours at 150°F in order to assure a moisture removal of 13%. This in an air dryer which also serves as a preheat chamber just prior to the extrusion process.

3.2.2 Venturi Tube Pneumatic Conveyor

Figure 11 shows a venturi conveying system. Negative pressure is produced in the venturi (12) - a vacuum

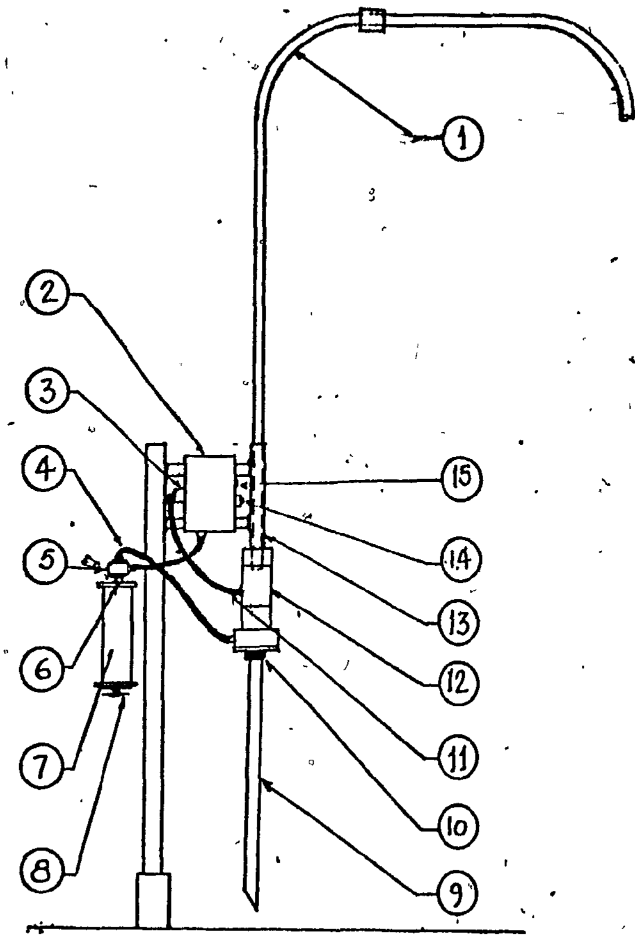

FIG. 11 OUTLINE SCHEMATIC VENTURI CONVEYOR
Reference 9

1 Conveyor tube
2 Control box (See Fig. 12b for details)
3 Vacuum switch
4 Air hose
5 Air regulator
6 Air inlet
7 Air filter
8 Drain
9 Pick-up tube
10 Vacuum control hose
11 Grommet
12 Venturi
13 Support bracket
14 Push-button switch
15 Selector switch

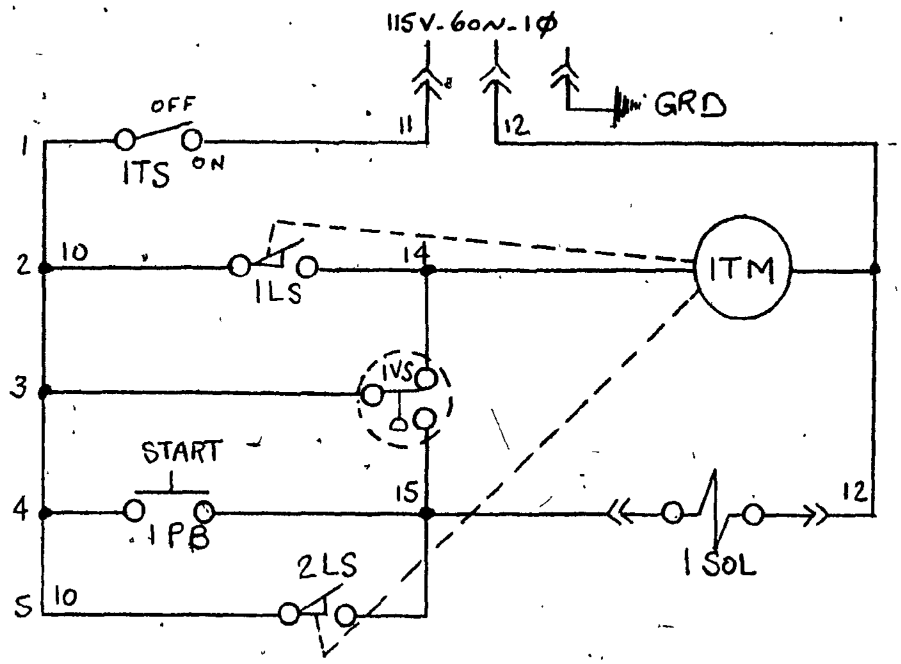

FIG. 12a CIRCUIT DIAGRAM OF AUTOMATIC LOADING CONTROL OF PNEUMATIC VENTURI CONVEYING SYSTEM
Reference 9

SEQUENCE OF OPERATIONS

1 With 1TS in "on" position, 1TM runs (thru 10, 14), driving cam which operates 1LS and 2LS.

2 1LS closes, 1TM maintained. 2LS closes, 1SOL energized, compressed air passes into venturi. Vaccum created operates 1VS, 1SOL maintained.

3 2LS opens. 1LS opens. 1TM stops.

4 Conveyor loads until machine hopper is full. Back pressure reduces vacuum in venturi. 1VS opens. 1SOL de-energized. 1TM runs.

5 2-1/2 min. later, 1LS closes. Steps 2 thru 5 repeat.

NOTE: See FIG. 12b for connection diagram and FIG. 12c for symbol description.

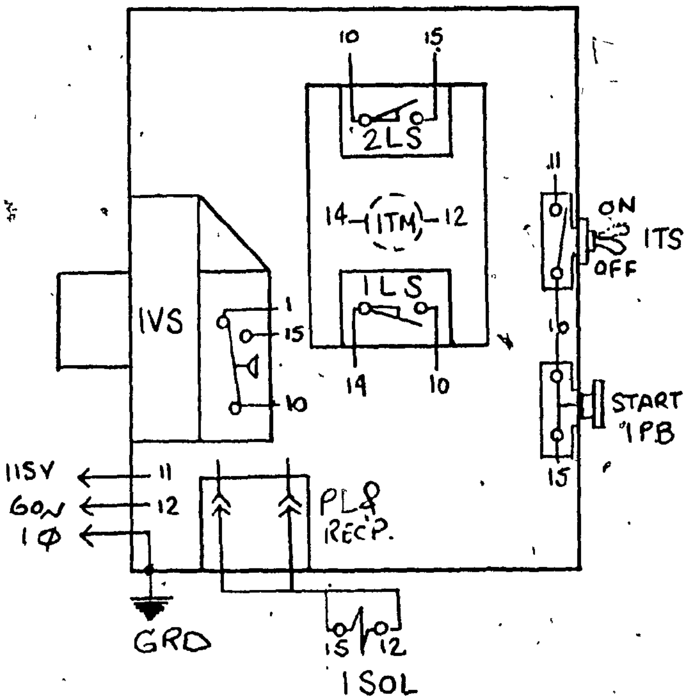

FIG. 12b CONNECTION DIAGRAM OF AUTOMATIC LOADING CONTROL OF PNEUMATIC VENTURI CONVEYING SYSTEM
Reference 9

SEQUENCE OF OPERATIONS

1 With the toggle switch 1TS in "on" position, the timer motor 1TM starts.

2 Starter button PB is to be pressed and held until solenoid air valve 1SOL will open.

3 The conveyor will operate until the receiver is full and will then shut off for the time intervall of the cam, and start again feeding material as required.

4 The starter button PB will manually start the unit at any time.

NOTE: See FIG. 12c for symbols and description.

SYMBOLS AND DESCRIPTION		
SWITCHES		
	Push button Normally open	PB
	Limit Held open	LS
	Vacuum Held closed	VS
	Vacuum Held open	VS
	Toggle Standard duty	TS
COILS		
	Timer motor	TM
	Solenoid	SOL
MISC.		
	Plug Receptacle	PL RECP
	Ground	GRD

FIG. 12c DESCRIPTION OF SYMBOLS USED IN THE CIRCUIT DIAGRAM OF AUTOMATIC LOADING CONTROL OF VENTURI CONVEYING SYSTEM
Reference 9

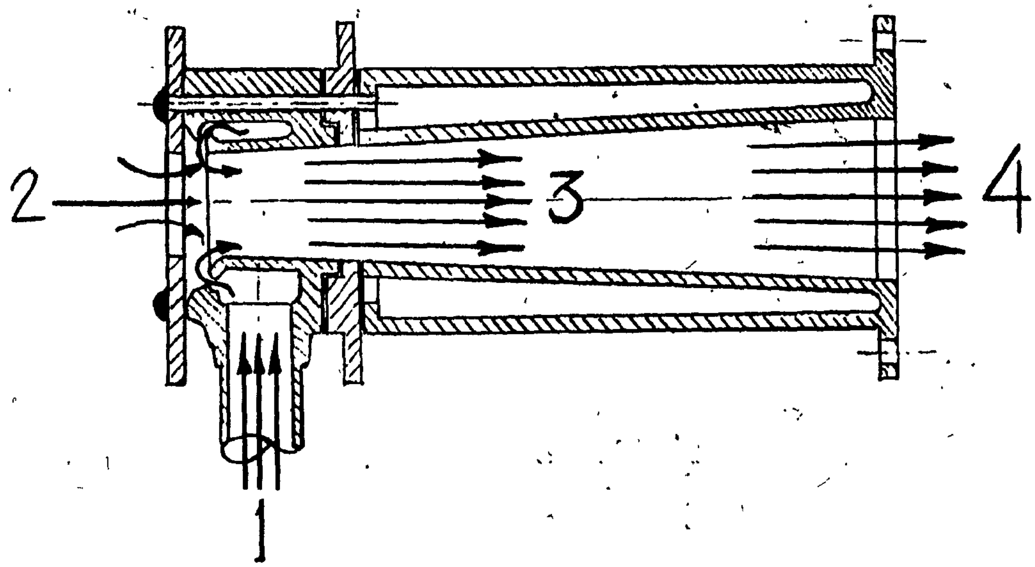

FIG. 13 VENTURI TUBE, AIR-FLOW OUTLINE
Reference 11

1 Primary supply enters the manifold via annular gap and accelerates over the aerofoil
2 Conveyed material or secondary supply is induced into the throat of the manifold
3 Mixing in the divergent tube
4 Discharge at high velocity

chamber not being required in this system. Plastic pellets are sucked from the container through the pick-up tube (9) to the extruder hopper through conveyor tube (1). This system uses dry compressed air for its power, so it requires electricity only for loading control. Selector switch (15) can provide either manual or automatic loading control. Automatic control is accomplished by means of timer, solenoid valve, and two limit switches all contained in control box (2). For the sequential operations of the control box and electrical circuit diagram see figures 12a, b, c.

The venturi tube itself consists of an annular chamber surrounding a ring nozzle (see figure 13). Compressed air flows from a small inlet into the annular chamber, and passes over the annular gap. This primary supply air is then throttled through the ring nozzle radially inwards and perpendicular to the center line of the venturi tube. For most inlet pressure, the air attains sonic velocity in the nozzle throat. The throttling or expansion of the primary supply and the subsequent acceleration create a region of depression (negative pressure) which induces secondary air flow into the throat. This secondary, or induced flow, which is in an approximate 20:1 ratio to the primary supply, mixes in the divergent tube. The result is a high velocity mixture of primary and secondary flows. Plastic pellets are sucked from the container and conveyed with the secondary flow to the extruder hopper.

3.3 CONCLUSION

The characteristic advantages of venturi tube conveyor over the vacuum pump system are, usually: lower initial cost and operating cost; no moving parts; high reliability; low maintenance cost; no guards required; more compact size; much quieter operation; and low compressed air consumption. Balanced against these advantages are the negative facts that venturi tube has low efficiency and is limited to single conveying application.

Output of a venturi tube can be controlled over a wide range by using a pressure regulator to control the pressure supplied to the unit. Thus, this device can perform the function equivalent to that of a complex variable speed and variable pitch fans.

The venturi principles can be applied to cooling, drying, humidifying with spray mist, and ventilation operations. It can be used to remove welding fumes, and to reduce temperature and humidity in steel mills and foundries where excessively high working temperature and humidity exist. The venturi principle can efficiently provide jets of air for safe ventilation of explosive or toxic areas, such as petrochemical and gas processes. This flow is created without the use of electricity or moving parts.

CHAPTER IV

HYDRAULIC TRAVERSING SYSTEM FOR WIRE AND CABLE BOBBIN WINDING MACHINES

CHAPTER IV

HYDRAULIC TRAVERSING SYSTEM FOR WIRE AND CABLE BOBBIN WINDING MACHINES

4.1 REQUIREMENT OF UNWINDING, WINDING, AND TRAVERSING OPERATION IN THE WIRE AND CABLE MANUFACTURING INDUSTRY

In the Wire and Cable manufacturing industry, operations such as wire drawing, stranding, conductor insulation, cable painting, patching, inspection, armouring and jacketing require that wire or cable should be unwound from one reel, pulled and processed through one of the above operations, then wound on to another reel. The bulk of production lines in this industry are devoted to these three functions (unwinding, processing, rewinding). Traversing techniques are used in the winding operation in order to provide for a cylindrically uniform winding. In the following sections the three operations of unwinding, winding, and traversing will be outlined in further detail.

4.2 UNWINDING

Unwinding of wire or cable is performed on a stand commonly called a "let-off stand". It is a non driven operation in which the reel is mounted on a spindle or between two pintles and left free to rotate. In general, let-offs vary in size according to reel diameter, width, and load. They also vary in type. Heavy reels require special foundations for floor-type stands. The TUT type (figure 14) is comprised of bearing beams from which the pintle arms are

FIG. 14a TRIPLE TAKE-UP STAND, TYPE TUT FOR USE WITH CONTINUOUS EXTRUSION LINE. THE LET-OFFS HAVE SAME CONSTRUCTION BUT WITHOUT TRAVERSE, OR DRIVE. Reference 12

FIG. 14b TRAVERSING TAKE-UP STAND, TYPE TUT
WITH A TRAVERSING DRUM CARRIAGE
Reference 12

hung. For light loads, portable-type let-offs are commonly used. Reels can be loaded on or unloaded from portable let-offs manually, or by mechanical, hydraulic or pneumatic jacks. In the unwinding operation, when wire is pulled at high speed, accurate tension control is required. This tension is provided by using a brake with a torque retarder whose effect is proportionately lessened as the diameter of the coil of the unwinding wire or cable is reduced.

4.3 WINDING TECHNIQUES

Fine wire winding is performed on spoolers (wire diameter from 0.064" to 0.001"), while "take-ups" are used to wind larger diameter wire or cable. Spoolers and take-ups are powered by either the main motor of the line operation, or by an independent motor. Structures and types of take-ups are similar to these of let-offs with the exception that take-ups are equipped with traversing mechanisms.

In the winding operation, as the spool diameter increases, the speed of the driving motor must be decreased to keep a constant linear speed while holding the wire or cable in tension. Constant tension at a constant linear speed requires constant horsepower over the entire range, regardless of how the motor speed varies with ~~the~~ diameter of the spool. Also, the torque exerted by the spooler or take-up must be increased in direct proportion ~~to the~~ diameter of the coil of cable or wire. Automatic speed control can be accomplished by electro-mechanical, electrical, mechanical, hydraulic, or electro-means. More detailed information on the use of all of the above winding techniques is presented in Appendices A, B, C, D and E.

4.4 TRAVERSING TECHNIQUE

Take-ups or winders are usually equipped with an automatic traversing system, however, manual traversing is carried out when winding large diameter and heavy cable. The purpose of the traversing system in winding operations is to guide and distribute wire or cable on take-up reels, in a cylindrically uniform pattern.

In general, the traversing system consists of a guide carriage (mounted on a traverse axis) which oscillates between two stops. The linear speed of the carriage with respect to the rotational speed of the reel determines the traversing "PITCH", which is defined in terms of either meters per revolution or inches per revolution. In order to obtain a fine winding, the traversing pitch should be as close as possible or equal to the diameter of product to be wound.

The traversing system is always driven from the take-up or winder drive. As the rotational speed of the winder gradually decreases in proportion to the increase in reel diameter, the traverse linear speed is automatically governed to follow these changes; and thus, the traverse pitch is kept constant - regardless of winder rotational speed.

In the following sections conventional meohanical and hydraulic systems are outlined. Other systems, such as electro-mechanical, pneumatic, and more advanced mechanical approaches are also outlined in the Appendices F, G and H, consecutively.

4.4.1 Conventional Mechanical Traversing System

Figure 15 shows a conventional mechanical traversing system. A screw shaft (7) is employed to convert rotary motion into rectilinear motion. The shaft rotates between two fixed stop ends (4). The length of the screw shaft is selected in accordance with the range of reel widths to be handled. A specially designed nut, with external thrust surfaces is attached to the screw and connected to the guide carriage (8) in such a way that it is prevented from displacement or rotation and forms an integral part of the carriage. The guide carriage slides freely along a traverse bar (10), which carries two adjustable stop ends (4), and which is linked to the claw clutch (9). This guide bar is free to move laterally in order to engage the claw clutch. The claw clutch is used to reverse the rotational motion of the screw shaft. When the guide carriage reached the limit of its stroke, it impringes on the stop end deflecting the guide bar (10) to either side, thus allowing the clutch to reverse the rotational direction of screw shaft.

Figure 16 shows the basic elements of a claw clutch. The bevel gears (5 and 2), are mounted freely on the driven

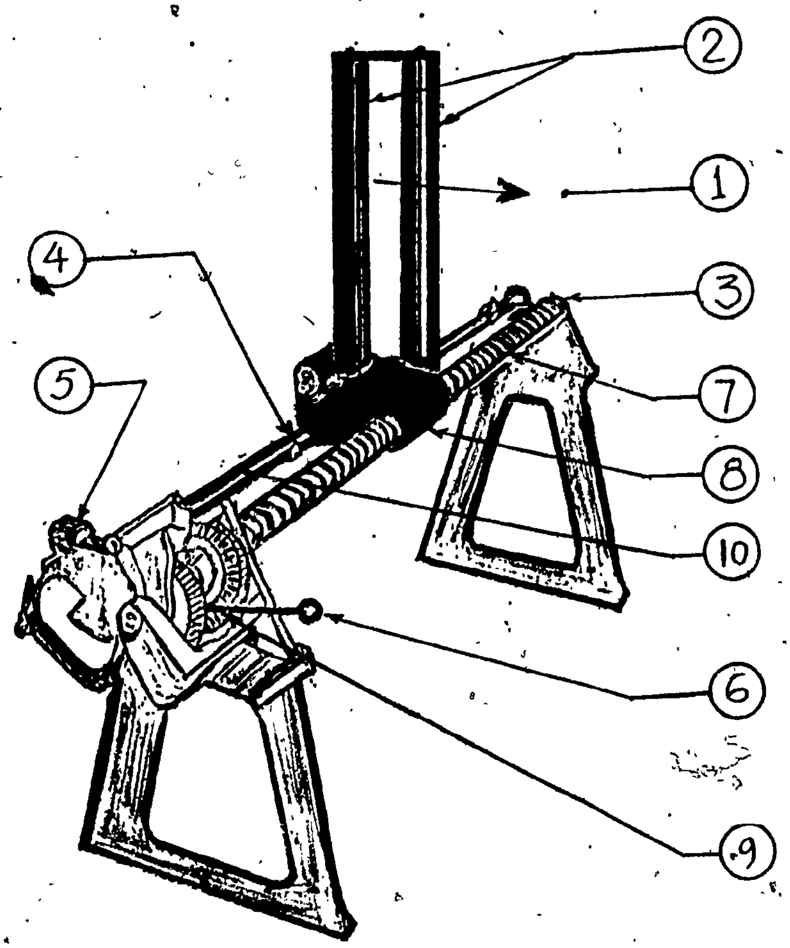

FIG. 15 CONVENTIONAL MECHANICAL TRAVERSING SYSTEM
Reference 13

1 Cable direction
2 Guide rollers
3 Power drive from take-up
4 Stop for end points
5 Lay adjustment
6 To disengage power drive
7 Screw
8 Carriage
9 Claw clutch
10 Guide bar

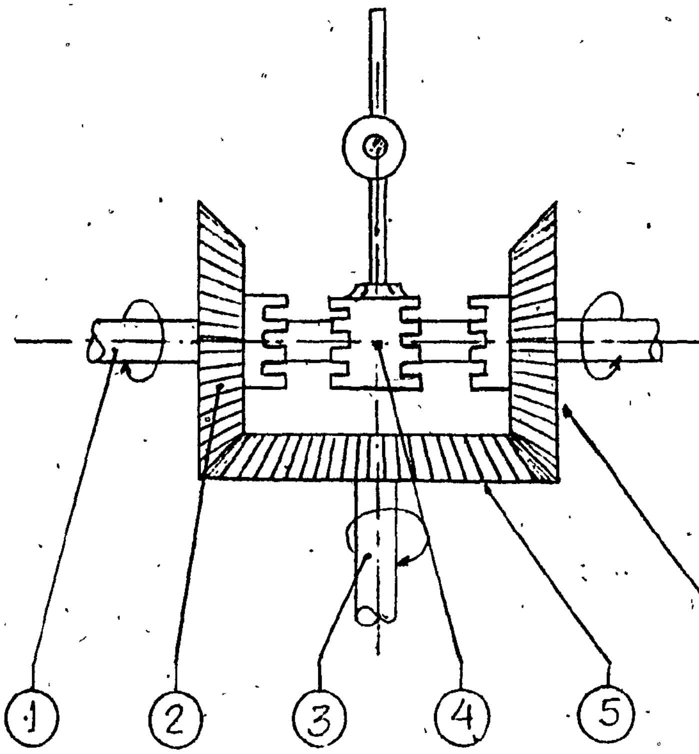

FIG. 16 CLUTCH - OPERATED
REVERSING MECHANISM
Reference 14

1 Driven screw shaft
2 Bevel gear
3 Idle shaft
6 Bevel gear
5 Bevel gear
4 Claw clutch

screw shaft (1), and are constantly in mesh with bevel gear (4) of the idle shaft (3). The bevel gears are running loose on the screw shaft and the claw clutch (6) slides along a key on the shaft between these gears. When the clutch is shifted to engage either gear, the driven shaft (1) will rotate in one direction or the other.

This system has two major disadvantages:

1. It is relatively inflexible, requiring change gears or a special transmission set-up in order to vary the winding pitch.
2. It is maintenance-prone since heavy thread shaft wear is normal.

4.4.2 Hydraulic Traversing System

Figure 17 shows a schematic diagram of hydraulic traverse flow circuit. The hydraulic traverse is operated by means of a hydraulic pump (2) which is mounted within the spooler housing and gear driven from the reel drive. Oil is pumped from the oil reservoir (1) by the gear pump (2) to a 2-position, 4-way, solenoid-actuated, spring-returned valve (7). This valve is controlled by two limit switches (8 and 9) arranged to be mechanically operated at either end of the traverse stroke. Oil is alternately pumped to either end of the traverse cylinder (10) and flows from the exhaust end to the reservoir. The limit switch (8) controls the rear or fixed traverse stroke position. The other limit switch (9) is mounted with allowance for adjustment so that the traverse

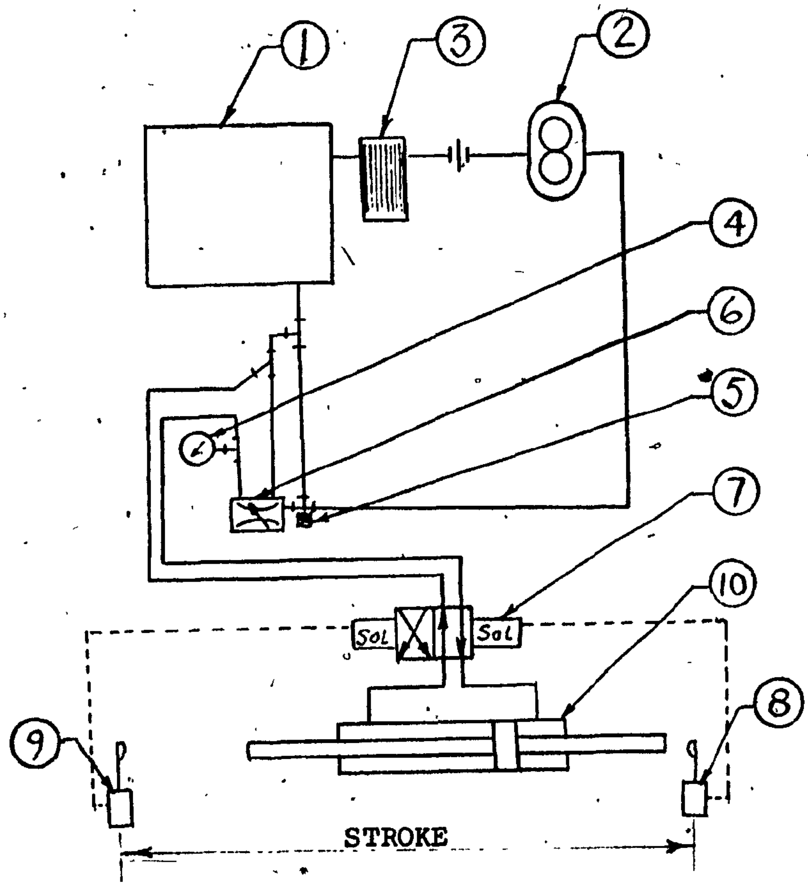

FIG. 17 HYDRAULIC TRAVERSING SYSTEM
Reference 15

1 Oil reservoir
2 Gear pump
3 Oil filter
4 Pressure gauge
5 Pressure regulator
6 Flow central valve
7 4-way valve, solenoid
8 Limit switch (fix)
9 Limit switch (adjustable)
10 Double action cylinder

stroke may be changed to suit the reel in use. The traverse hydraulic oil is cleaned by filter (3) in the pump suction line. The pressure regulator (5) assures a constantly regulated pressure to the flow control valve (6). Lay can be finely adjusted by use of the flow control valve (6) and the pressure regulator (5). Both act as a positive infinitely variable speed gear box. A pressure gauge (4) is used to correlate fluid pressure to the required pitches of different wire sizes.

Sets of change gears can be used between the drive reel and pump (2) to obtain the spooling pitch (or "lay") required for wire to be spooled.

For a given pump speed, the traverse pitch is inversely proportional to cylinder inside diameter and directly proportional to pump flow rate. This relationship can be stated as follows:

$$\text{Traverse pitch}\left[\frac{\text{inch}}{\text{revolution}}\right] =$$

$$\left[\frac{1}{\text{pump (rev. per sec.)}}\right] \times \left[\frac{\text{flow rate (in}^3\text{ per sec.)}}{\text{piston cross section (in}^2\text{)}}\right]$$

The desired range of traverse pitch can be obtained by selection from the different size alternatives of gear pump and cylinders.

4.5 CONCLUSIÓN

A conventional mechanical traversing system incorporates moving parts which are subject to wear. Regular routine maintenance such as lubrication, checking and/or replacing noisy gears, worn-out bearings, broken chains, and slack belts are essential in order to assure continuity of production. However, when a breakdown occurs, unless it is of a very minor nature, a tradesman is required to effect repairs - usually replacement of a worn or broken part. Hence these direct costs are immediately incurred - the cost of labor, the loss of production revenue, and the cost of the replacement part (including inventory carrying costs if an in-plant supply is maintained).

Hydraulic traversing offers a system which employs relatively few moving parts. Its components are fairly standard and are inexpensive when compared to equivalent components of a mechanical system. No stocking of hydraulic components is required since they are available "off the shelf" at any hydraulic equipment supplier.

The circuit follows simple principles, and maintenance can be performed by anyone who has a practical knowledge of basis pipefitting techniques.

Hydraulic system is very reliable in high speed winding application (i.e. 5,000 feet per minute), and is also very efficient in fine winding applications both for wire (as small as .001" diameter) and cable up to 1" diameter.

Maintenance is ~~generally~~ limited to checking and/or changing the oil filter.

Traverse speed control does not require changing gears. The fast speed setting is provided by means of pressure regulator and flow control valves.

CHAPTER V

CONCLUDING REMARKS

CHAPTER V

CONCLUDING REMARKS

Three fluid control systems combined with electrical/ mechanical control systems used in the Wire and Cable manufacturing industry are described in this report, and are compared to conventional control systems. From these specific applications, it is possible to draw general conclusions as to the advantages offered by combined fluid control systems over conventional systems:

1. They are simpler in construction, having few, if any, moving parts. Since there is less to go wrong with the system, the system is more reliable.

2. They are less expensive to maintain and operate since:

   a) Lubrication is generally not required.

   b) Special trade skills are not required for repair work - a reasonable knowledge of pipefitting being the basic requirement.

   c) Spare parts are usually standard off-the-shelf items, thus requiring a minimum spare parts inventory - depending on geographical location.

3. They are more compact in size and are more quiet in operation. This latter advantage is becoming steadily more important in view of the increasing emphasis being placed by Government and Industry on pollution abatement - pollution including excessive noise.

Specific examples which reflect the above-claimed advantages in the body of this report are:

Air Jet Damper

The main parts which are exposed to the corrosive environment of the furnace (exhaust gases) are simply 4 inch long pipe nozzles which are welded directly onto the flue stack. These take the place of the conventional air damper which is comprised of several moving parts and must be built with materials having a high degree of resistance to exhaust gases.

Venturi Tube Conveyor

The divergent tube and the annular ring are the main parts of the venturi conveying mechanism. This system replaces the positive displacement vacuum pump which is comprised of more than 25 components (mainly mechanical transmission parts) and an electric motor. Assembly and maintenance of a positive displacement pump requires skilled machinists.

Hydraulic Traversing System

The hydraulic cylinder, hydraulic pump, the 4-way valve and oil reservoir are the main elements of this system. These take the place of the conventional mechanical traverse which is comprised of mechanical transmission parts and are more subject to mechanical wear and breakdown.

APPENDIX "A"

ELECTRO-MECHANICAL WINDING TECHNIQUE

APPENDIX "A"

ELECTRO-MECHANICAL WINDING TECHNIQUE

Figure 18 shows an electro-mechanical winding system installed on a syncro fine wire drawing machine (wire diameter from 0.064" to 0.002"). The control mechanism contains a contact arm (6) which holds a contact roller (probe) (1) at its end. At start-up, the contact probe is almost touching the spool (not shown). When the spooler is started, the wire builds up on the spool until it makes contact with the probe. The making of this contact energises a solenoid (9) connected to the probe and moves the probe away from the wire. At the same time another solenoid (14) is energised by contact on a relay in the electronic control box. This solenoid being connected to a ratchet mask allows a pawl to engage the ratchet (10), and an operating arm revolves a worm shaft (11) and worm gear (12). As the operating arm completes its stroke, a switch (normally closed) opens and de-energises the relay in the electronic unit which in turn re-sets both solenoids, preparing them for the next operation. The movement of the worm gear (12) alters the setting of the infinitely variable (cone and ring) gear (15), thus reducing the spool R.P.M.

Attached to the worm gear (12) is a speed control cam (5) which displaces the follower (13) fixed on the same shaft as the contact arm (6). Thus, as the speed is reduced, the cam is rotated in an anti-clockwise direction, and the contact arm is retracted to the next position of contact.

This sequence is repeated as the spool diameter again builds up.

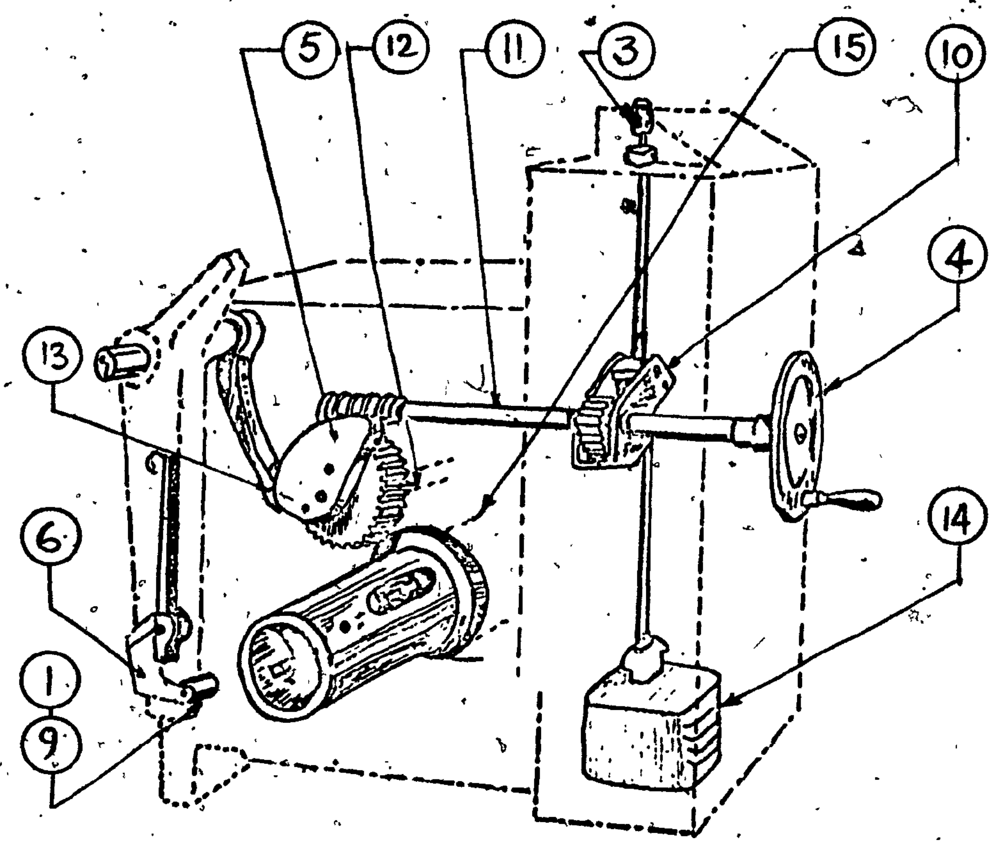

FIG. 18a ELECTRO-MECHANICAL WINDING SYSTEM - INTERNAL MECHANISM
Reference 16

1	Contact roller
3	Ratchet release
4	Handwheel
5	Cam
6	Contact arm
9	Solenoid
10	Ratchet
11	Wormshaft
12	Wormgear
13	Follower
14	Solenoid
15	Cone & ring variable gear

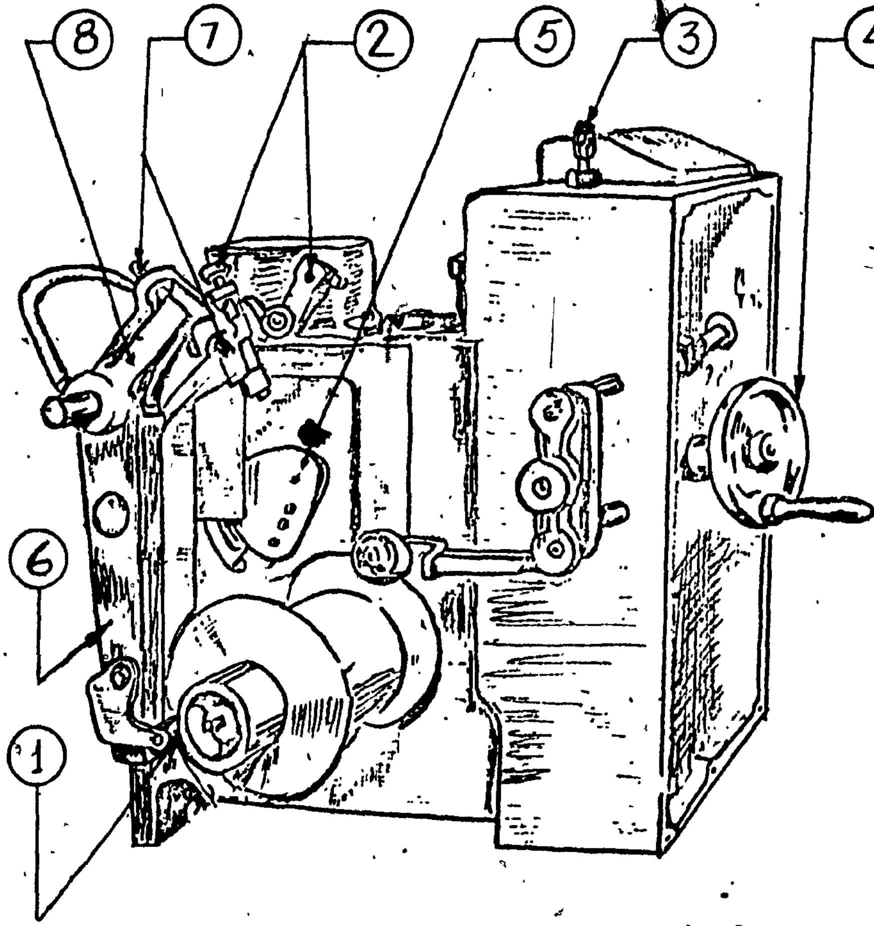

FIG. 18b ELECTRO-MECHANICAL WINDING SYSTEM - EXTERIOR VIEW
Reference 16

1 Contact arm roller
2 Full package switch adjustment
3 Ratchet release plunger
4 Crank handle
5 Speed change cam
6 Contact arm
7 Micromatic adjustment
8 Contact arm holder

APPENDIX "B"

ELECTRICAL WINDING TECHNIQUE

APPENDIX "B"

ELECTRICAL WINDING TECHNIQUE

Electrical speed control is generally characterized by the ease with which relatively small changes in voltage and current can effect changes of very large magnitude in the power circuit and motor output speed. Variable speed drives can be classified into the two categories.

1. Adjustable speed from an A.C. power source.
2. Adjustable speed from a D.C. power source.

A description (the principles of operation) of each system is outlined below.

1. <u>Adjustable Speed From an A.C. Power Source</u>

This type of drive is known as "Eddy current drive". The input member operates at constant speed provided by an A.C. motor. Figure 19 shows the different components of this type. The pole assembly (2) which is a part of the input member (1), rotates at a constant speed between the stationary field coil (3) and the inertia output rotor assemblies (4). There is no mechanical connection between the input member (1) and the output rotor (4). By exciting the stationary field coil with low voltage D.C. provided by a separate controller, a magnetic field is developed around the coil (3). Magnetic lines of flux pass from the stationary field coil (3) to the constant speed input member pole piece (2), through the working

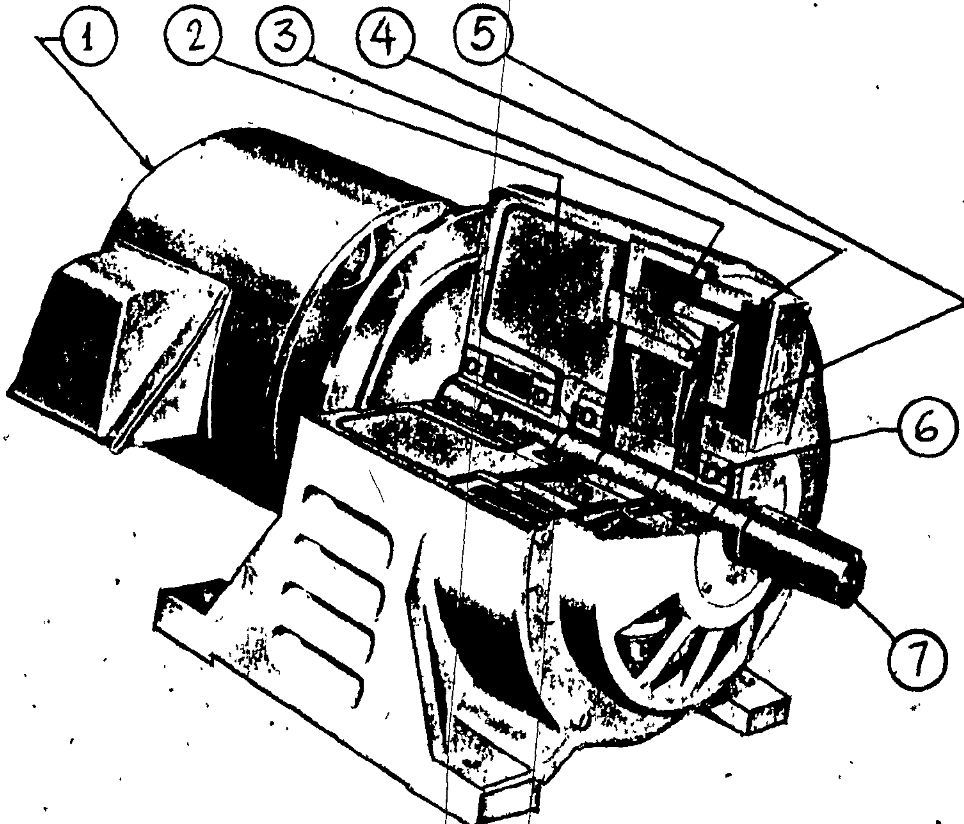

FIG. 19a EDDY CURRENTS DRIVE

1 Standard nema "d" flange motor
2 Constant velocity input fan-pole assembly
3 Stationary field coil
4 Low inertia output rotor
5 A.C. tachometer
6 Heavy duty widely-spaced ball bearing
7 Variable speed output shaft

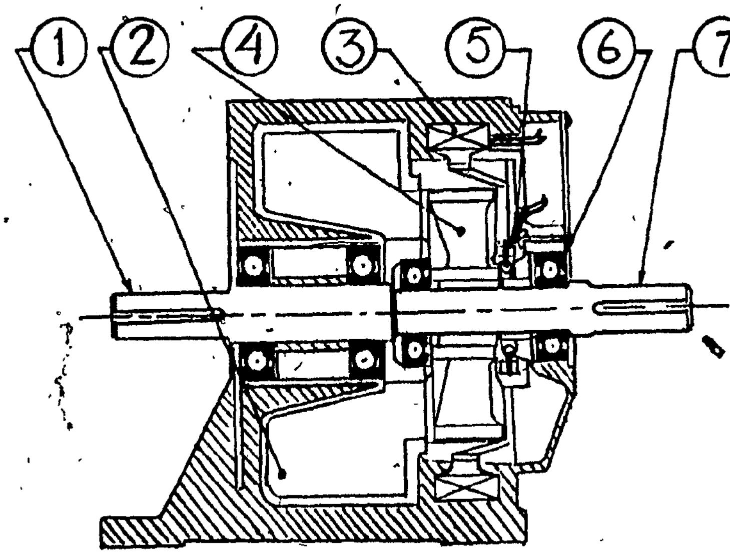

FIG. 19b ADJUSTABLE SPEED FROM AN A.C. POWER SOURCE
- EDDY CURRENT DRIVE -

air gap and into the low inertia output rotor (4). The amount of flux in the output rotor changes as relative speed occurs between the input member and the low inertia output rotor (4). This changing flux in turn produces Eddy currents and an associated magnetic field which is attracted to the originating field. Thus, the low inertia rotor (4) of the clutch is magnetically attracted to the input member (1). The torque created is a function of the voltage applied to the stationary coil (3) and the relative speed between the constant speed input member and the low inertia output rotor. Therefore, by varying the applied voltage, the output speed is varied.

The separate controller utilizes a regulated reference voltage. The A.C. tachometer (5) in the drive produces a voltage proportional to the actual output speed. In setting the precision potentiometer, a portion of this reference voltage is established as linear speed of the operation line or desired tension. This is then continually compared with the speed or tension transducer voltage outputs which are indicative of the actual drive parameters obtained. The control senses any deviation between the reference established and the drive operation obtained and as a result changes the excitation level to the Eddy current clutch in the direction necessary to reduce the speed.

2. <u>Adjustable Speed From a D.C. Power Source</u>

In D.C. motors there are two common methods of speed control, varying the impressed voltage and thus the generating voltage, or varying the field flux. The most common method of speed control is to change the shunt-field excitation and thus, the field flux. This is generally accomplished by introducing a resistance into the shunt-field circuit. The motor speed and hence the line speed is controlled by the armature voltage applied to the motor by the power unit. This excites the main field of the power unit. A controller, which is a self-balancing device, constantly compares a speed reference signal with a feedback signal from a tachometer driven by the winder motor.

A second method of speed control is accomplished by lowering the impressed voltage and thus the speed of the D.C. drive. This can be accomplished by applying a counterbalanced float roll (see figure 20) which, in rising and falling with the cable catenary, operates a lever which controls the output voltage from a transformer to the main drive.

This type of counterbalanced float roll controller provides for winding without cable tension other than that tension produced by the cable's catenary weight.

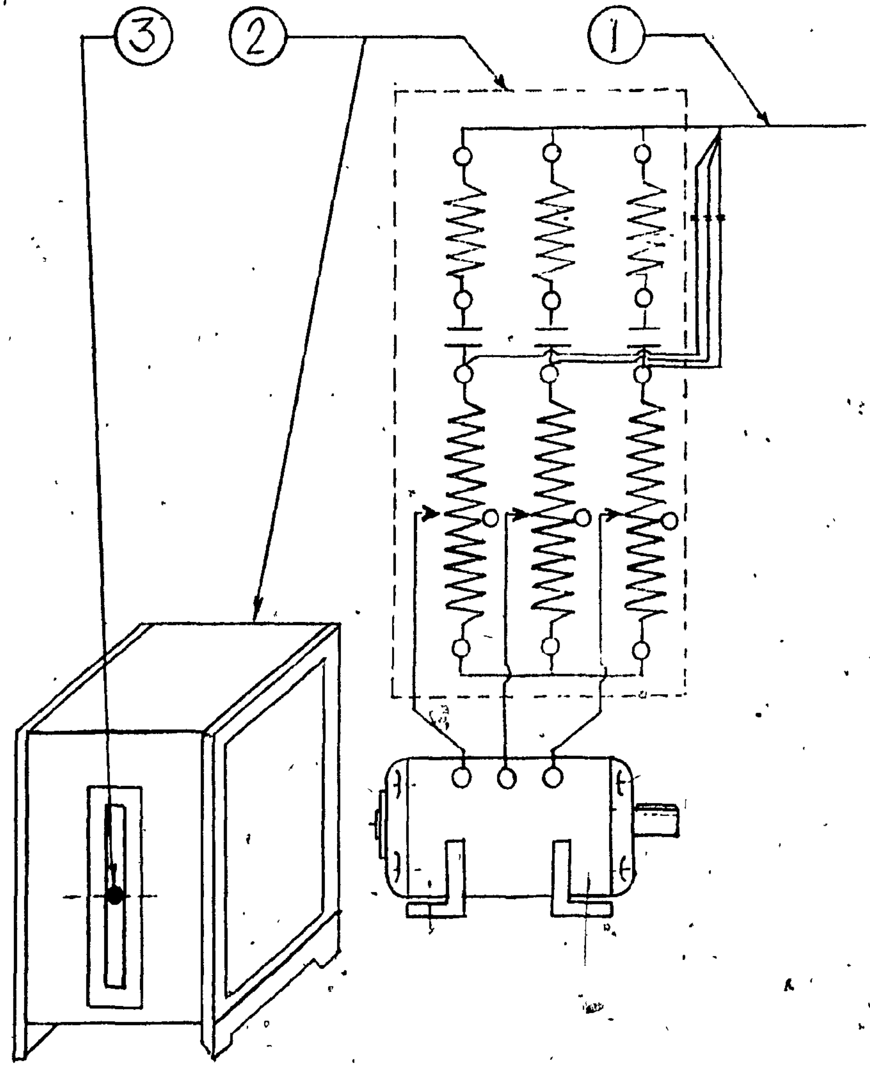

FIG. 20 ADJUSTABLE SPEED FROM A D.C. POWER SOURCE BY LOWERING THE IMPRESSED VOLTAGE

1 Power supply
2 Autotransformer
3 Lever connected to floating roll

APPENDIX "C"

MECHANICAL WINDING TECHNIQUE

APPENDIX "C"

MECHANICAL WINDING TECHNIQUE

1. Slip Clutch

Figure 21 shows single steel plate (5), with friction material attached to both sides, mounted between two friction surfaces (4) on the inner hub (3). The lining plate engages a gear tooth drive ring attached to the sleeve of the clutch. A series of springs (1) compressed the plate (5) between the friction surfaces (4). A sliding collar (2) at the end of the hub (3) permits the changing of the torque value while the mechanism is in operation. In the winding operation, as the reel gradually grows in size and torque applied must consequently increase proportionally to maintain the required tension, the slip in the clutch decreases gradually, causing the speed to decrease.

The torque output and hence the desired line tension is proportional to the pressure on the adjusting collar. The torque range can also be increased or decreased by use of different sets of springs.

This type of clutch has the major disadvantage of generating more heat than it can dissipate. This unfavorable heat value limits the applications of the clutch to small and intermediate load situations. Generally, this type of clutch requires periodic adjustment to compensate for plate wear.

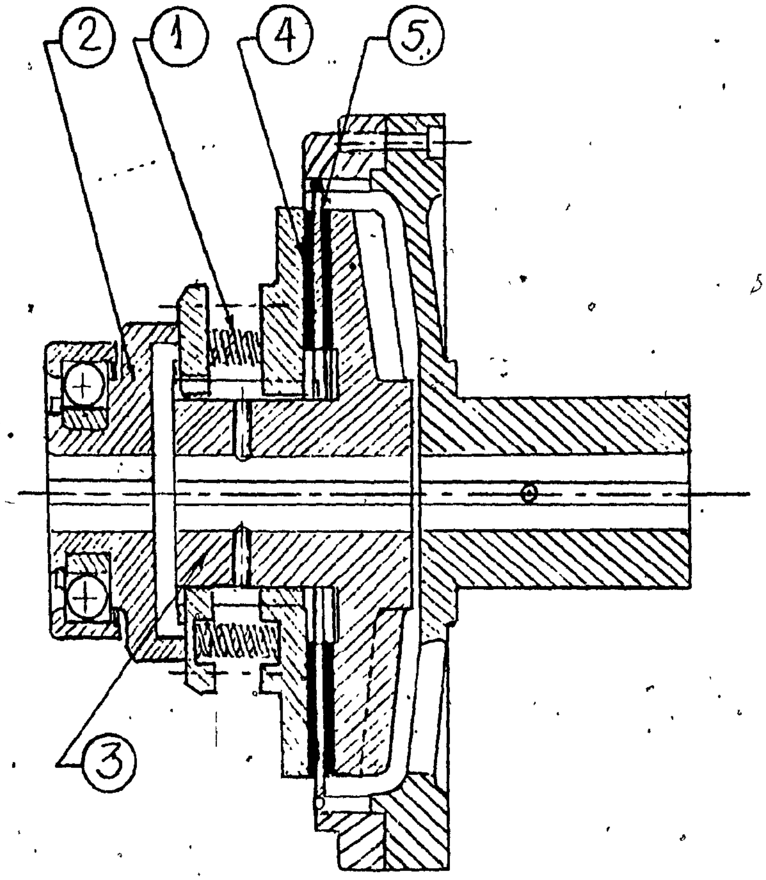

FIG. 21 SLIP COUPLING
(Adjustable on-line)
Reference 18

1 Springs
2 Collar
3 Hub
4 Friction plates
5 Steel plate

Greasing of parts which are subject to abnormal corrosion is important to prevent sticking or binding.

2. Dry Clutch

Figure 22 shows a dry clutch. The principle of operation is similar to that of a fluid drive except that instead of fluid, a heat-treated steel shot is the flow charge. A measured amount of the flow charge is contained in the housing, which is keyed to the drive member. When the drive member is engaged, centrifugal force throws the flow to the perimeter of the housing, packing it between the housing and the rotor member which transmits power to the load. The clutch is selected to handle the maximum load which the winder can carry. As the load (and hence the reel diameter) starts to increase, the "flow" thrown to the perimeter of the housing increases in proportion, thus transmitting more torque.

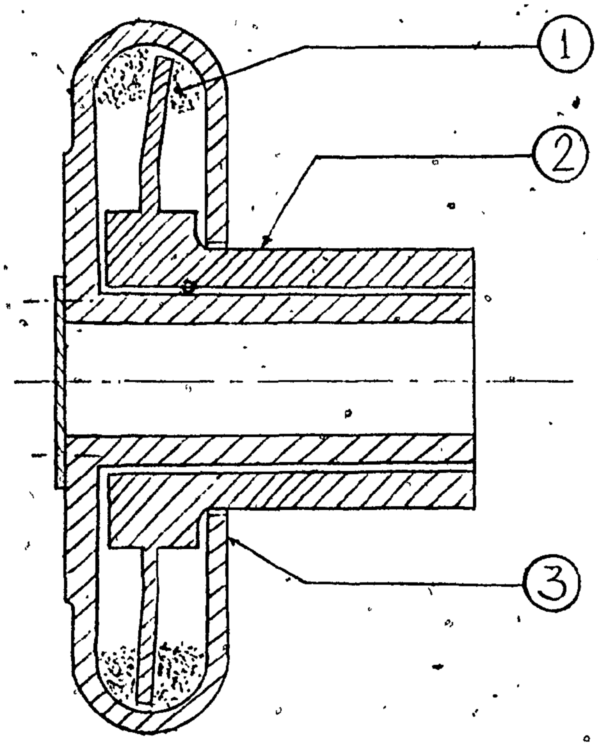

FIG. 22 DRY CLUTCH
Reference 19

1 Flow charge (heat treated steel shot)
2 Rotor
3 Housing

APPENDIX "D"

HYDRAULIC WINDING TECHNIQUE

APPENDIX "D"

HYDRAULIC WINDING TECHNIQUE

1. Dancing Arm

As previously mentioned, the counterbalanced float roll (known in the Wire and Cable manufacturing industry as a "dancing arm") operates under the tension imposed by the product's catenary weights.

In this system, the travel of the dancing arm is set between the desired upper and lower catenary tension limits, and is controlled by two limit switches. When the cable reaches the lower tension level, the dancing arm actuates the appropriate limit switch, and thus operates a gear pump through an electric drive. Oil is then pumped through a regulating valve to an hydraulic motor. The prime function of the gear pump (and the hydraulic motor) is to transmit power to the take-up reel through reduction gears. The take-up reel then starts to turn and wind the cable. At the same time, the dancing arm rises gradually until the cable reaches the upper tension level. At this point, the dancing arm actuates the upper limit switch which disconnects the motor. Consequently, the gear pump, gear motor and transmission of the take-up reel are shut down.

The torque transmitted by the hydraulic motor is directly proportional to the fluid flow rate, and reel diameter. The gear pump is selected to develop the desired torque at maximum load. When the gear pump is running, it develops a steady flow at a constant speed. A by-pass is provided to permit the return of excess fluid from the hydraulic motor during the gradually varying torque during the winding operation.

2. Hydraulic Torque Converter

This is similar in form to the hydraulic coupling with a set of stationary guide vanes added, and a reactor, interposed between the runner and the impeller. The major advantages of a torque converter are its ability to multiply starting torque and to act as a stepless transmission. Selection of hydraulic torque converters for specific applications is well-detailed in Standard Mechanical Engineering handbooks (reference 24) and is therefore not further discussed here.

APPENDIX "E"

WINDING BY MEANS OF A MAGNETIC PARTICLE CLUTCH

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WINDING BY MEANS OF A MAGNETIC PARTICLE CLUTCH

Figure 23 shows a magnetic particle clutch. In this type of coupling, the torque is transmitted from input to output members by an electro-magnetic field. The air gap between the two separated members is filled with ferrous powder (4) and surrounded by a coil (3). When the coil is energized, a high flux density is created. The torque transmitted by the clutch is proportional to coil current. The clutch is provided with control system which supplies a fixed amount of coil current, regardless of any change in resistance. The resistance of the coil is dependent upon the length, size and temperature of the wire which it contains. The length and size of the wire are fixed, but the temperature varies. An increase in coil temperature causes an increase in its resistance. Regulation of the current is achieved by automatically monitoring the output current and utilizing negative feedback within the control to keep the current at its pre-set value, regardless of any change in temperature, load resistance or incoming voltage.

In winding operations, the tension control is obtained as follows: (refer to figure 20b)
A weighted follower arm rests on the reel to sense reel diameter. The other end of the follower arm is pivoted on a sensor

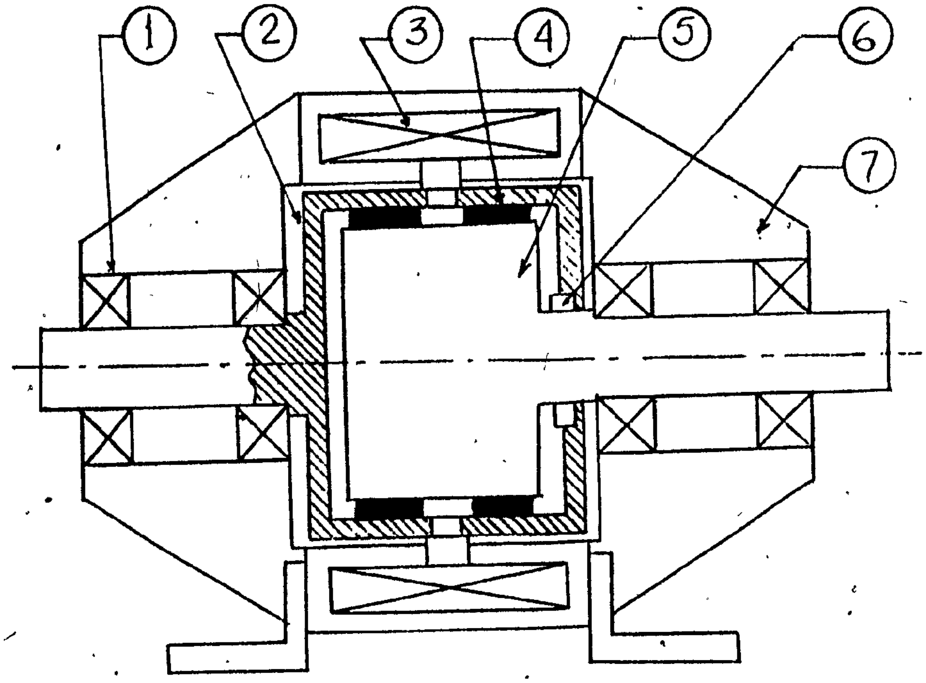

FIG. 23a SCHEMATIC OUTLINE SHOWING THE MAIN ELEMENTS OF MAGNETIC PARTICLE CLUTCH
Reference 20

1 Bearing
2 Drive cylinder
3 Coil
4 Magnetic power
5 Rotor
6 Shaft seal
7 Stator

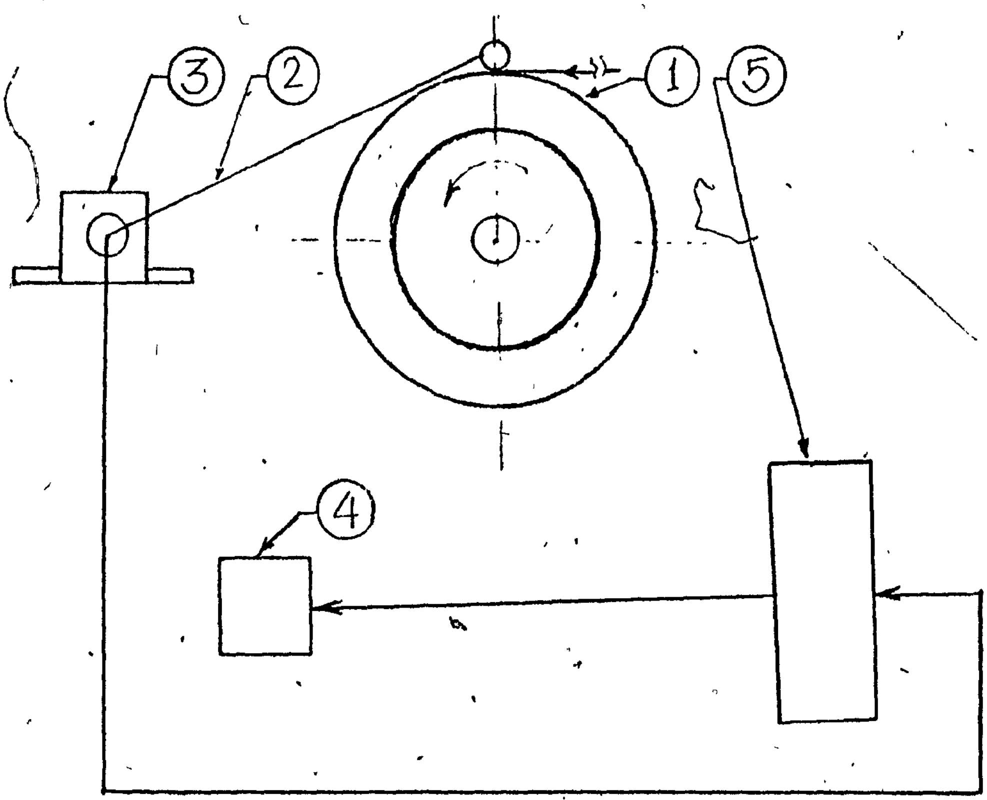

FIG. 23b BLOCK DIAGRAM SHOWING AUTOMATIC TENSION CONTROL BY MEANS OF MAGNETIC PARTICLE CLUTCH
Reference 20

1 Cable in winding direction
2 Follower arm
3 Sensor
4 Magnetic particle clutch
5 Controller

which apportions current as a function of roll diameter.

Current from the sensor is transmitted to the controller, thus varying the coil current in the clutch. This supplies the torque required to maintain constant line tension.

APPENDIX "F"

ROLLING RING TRAVERSE MECHANISM

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ROLLING RING TRAVERSE MECHANISM

Introduction

This system was invented and patented by Joachim Uhing, who was born in Kattowicz, Germany. Starting in 1943, he managed his own company in his present plant in Kiel-Schulensee, and from 1954 on, has made rolling gears, for which he holds twenty-one patents in his own and other countries.

Principle of Operation

In this system, the clutch-operated reversing mechanism is eliminated. The screw shaft is replaced by an unthreaded friction shaft which rotates in one direction only. Setting of traverse length is infinitely variable and is not limited by thread length as it is in the conventional method. Finely stepped instant setting of pitch is achieved by manually resetting a lever in the traverse mechanism by means of a knob and calibrated dial. Thus, the system needs no lead screw, variable speed drive, or change gears.

The conversion of rotary motion into linear reciprocating motion is based on the principle that contact pressure created between a correctly dimensioned ring and shaft assembly enables significant traverse forces to be transmitted.

System Description

Figure 24 shows three rings running on a smooth shaft (friction contact condition). These three rings are pivotable around the axes laterally to the shaft by $\pm 15^{\circ}$ and are interconnected in such a way that their planes with respect to the shaft axis form identical angles. The I.D. of the rings is 20 to 25% larger than the shaft diameter. The running surfaces of the rings are crowned, and contact the shaft alternately on two opposite circumferential lines, displaced by 180°.

Spring load provides the required friction contact between the three rings and the shaft. In most cases, spring pressure is applied to a single ring, and the spring load and therewith the side thrust pressure, can be varied over a wide range.

At a constant shaft rotary speed, the three rings are moved along it, the speed of their motion increasing with their pivot angle. In order to be able to vary this angle, the axis of the center ring protrudes from the housing. It is connected to a mechanical instant reversal switch (see figure 25). The reversal switch (5) has a spring which is designed to keep the rings at the largest pivot angle, in either direction.

Conclusion

This approach requires minimum maintenance, however, it does require machine tool grade accuracy in manufacturing

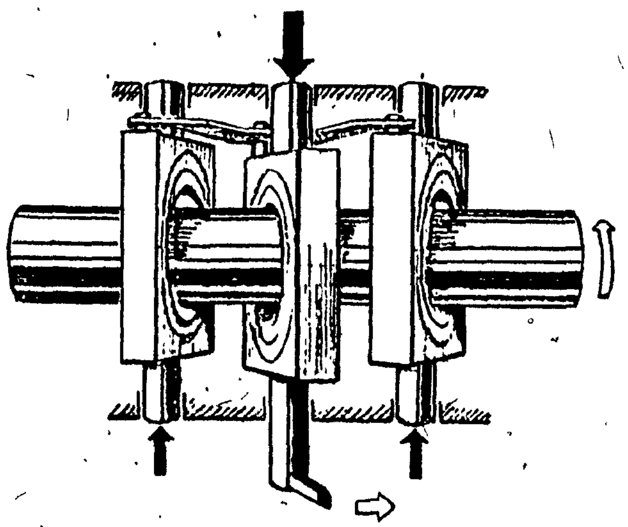

FIG. 24 PRINCIPLE OF ROLLING RING TRAVERSE
Reference 21

- Three rings are pivotable around the axes laterally to the shaft by $\pm 15^{\circ}$.
- Contact pressure created between the correctly dimensioned rings and shaft assembly enables significant traverse forces to be transmitted.

APPENDIX "H"

ELECTRO-MECHANICAL TRAVERSING SYSTEM

In this system, linear motion of guide carriage is obtained by means of a chain drive which is attached to the carriage at one end and to a counterweight at the other. The chain is driven from the reel drive through an electro-magnetic reversing unit, speed variator, fast speed motor and speed reducer.

Reversing is initiated by proximity switches, located below the guide rollers. Traverse stroke and pitch are stepless adjustable.

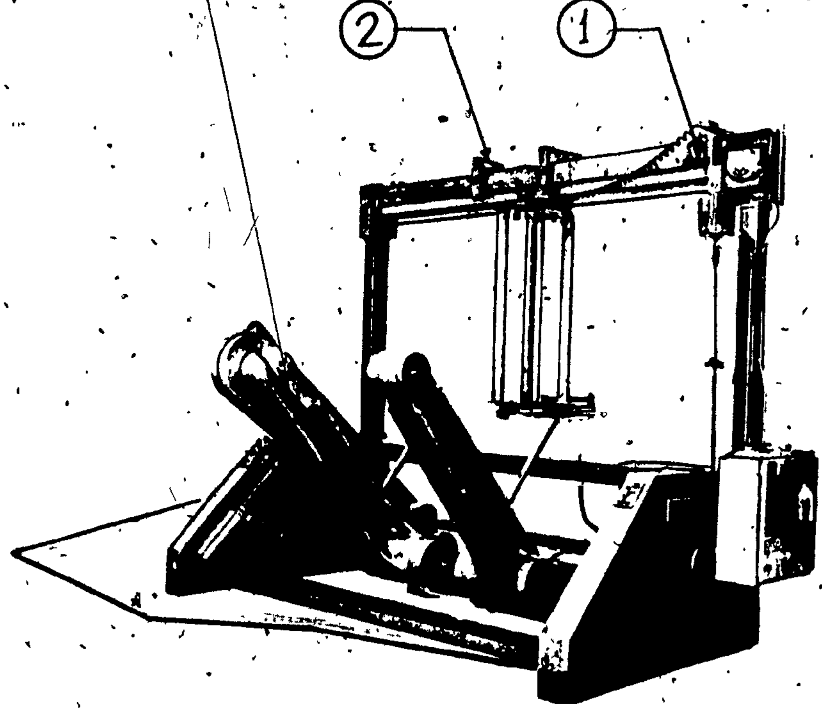

FIG. 27 SHAFTLESS TAKE-UP PROVIDED WITH
ELECTRO-MECHANICAL TRAVERSING SYSTEM
Reference 23

1 Limit switch
2 Carriage

REFERENCES

REFERENCES

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