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THE ELECTROLYTIC TINNING LINE of the EMPRESA NACIONAL SIDERÚRGICA, S.A. (SPAIN)

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Contents

THE ELECTROLYTIC TINNING LINE OF THE EMPRESA NACIONAL SIDERURGICA S.A. (SPAIN)

In 1971 the Empresa Nacional Siderúrgica, S.A. (ENSIDESA) (the National Steel Company of Spain) will enter the tinplate market with the starting up of a modern 40" electrolytic tinning line equipped with a process computer for the classification of the tinplate sheets and for recording data on the process and the products manufactured.

THE AVILES PLANT

1. The plant of the National Steel Company of Spain is an integrated works located at Avilés (Asturias), on the inlet of the same name, some 25 kilometres from Oviedo and Gijón.

2. This plant covers an area of some 5 million square metres and its installations are broadly as follows:

3. The plant has 10 batteries of coke ovens, representing a total of 300 ovens, with a total annual production capacity of 1,971,000 tonnes, 1,828,000 tonnes of which is blast furnace coke.

4. The pig iron is produced in 4 blast furnaces with a total annual production capacity of 2,500,000 tonnes.

5. The steel is produced in three steelmaking shops: an open hearth furnace shop with a production capacity of 700,000 tonnes per year, equipped with an active mixer for 600 tonnes of pig iron, three 300-tonne tilting furnaces and two 200-tonne fixed furnaces; an LD oxygen converter shop (LD-I) with three 70-tonne converters with a total production capacity of 1,400,000 tonnes per year, and a second LD oxygen converter shop (LD-II) with two 100-tonne converters with a total production capacity of 1,000,000 tonnes per year.

6. The second LD shop has an adjoining continuous casting plant with three curved vertical casting machines, each with 6 lines, capable of casting the entire output of the steelmaking shop into square-section billets with side dimensions of 75-200 mm.

7. The rolling facilities consists of two rolling shops; the West Rolling Shop and the East Rolling Shop.

8. The main installation in the West Rolling Shop are: a battery of soaking pits with 20 pits; a 42" (1,066 mm) blooming - slabbing mill with a rolling capacity of 700,000-1,000,000 tonnes of billets; a 32" (812 mm) reversible two-high 3-stand structural sections mill capable of rolling some 275,000-300,000 tonnes of sections and rails per year; a 132" (3,352 mm) reversible four-high slab mill capable of rolling 500,000 tonnes of slab per year including the breakdown for the coiler tension rolling mill; a 47½" (1,206 mm) reversible four-high coiler tension hot strip mill with an annual production capacity of about 300,000 tonnes and lastly, a combined plate and strip slitting mill for hot-rolled strip (figure 1).

9. The East Rolling Shop at present has the following installations: a battery of soaking pits with 32 pits; a 46" (1,168 mm) universal slabbing mill with an annual rolling capacity of 2,000,000 tonnes; a 62" (1,575 mm) pickling line with a capacity of 540,000 tonnes per year; a 66" (1,676 mm) 4-stand tandem mill with a production capacity of 800,000 tonnes of different thicknesses of plate per year; a battery of annealing furnaces with 34 single-pile furnaces and 90 bases, with a capacity of 480,000 tonnes per year; a 66" (1,676 mm) temper rolling mill with a capacity of 600,000 tonnes per year, and finally a cold rolled plate slitting line and a strip slitting line (figure 2).

10. The plant has a thermal power station to supply its various sections with electric power. The power station uses coal slack or blast furnace gas as fuel and has four generating sets with a total capacity of 105,000 kW.

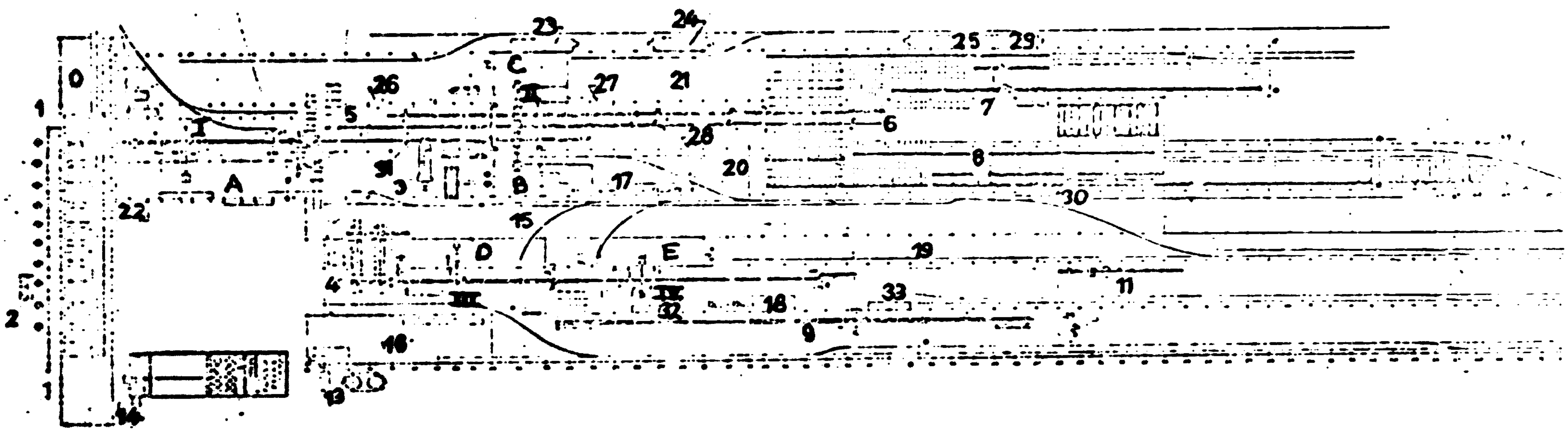
11. In order to supply the oxygen needed in the steelmaking shops and for deseaming and oxygen cutting, there is an oxygen plant with three air fractionation lines: one with a capacity of 6,000 m^3/h of oxygen and 5,600 m^3/h of nitrogen and two with capacities of 8,000 m^3/h of oxygen, 300 m^3/h of liquid oxygen and 5,600 m^3/h of nitrogen.

12. In addition, the coke oven gas is fractionated to separate the hydrogen in a gas plant which has two gas compression lines, each with a capacity of 26,600 m^3/h, and two coke oven gas fractionating lines with capacities of 18,350 m^3/h of ammonia synthesis gas and 13,260 m^3/h of dehydrogenated gas.

13. A 2-line ammonia synthesis plant produces 320 tonnes per day of anhydrous liquid ammonia and a fertilizer plant with a production capacity of about 400,000 tonnes per year produces ammonium nitrate/calcium nitrate and complex fertilizers.

Figure 1

ENSIDESA - GENERAL PLAN OF WEST ROLLING SHOP

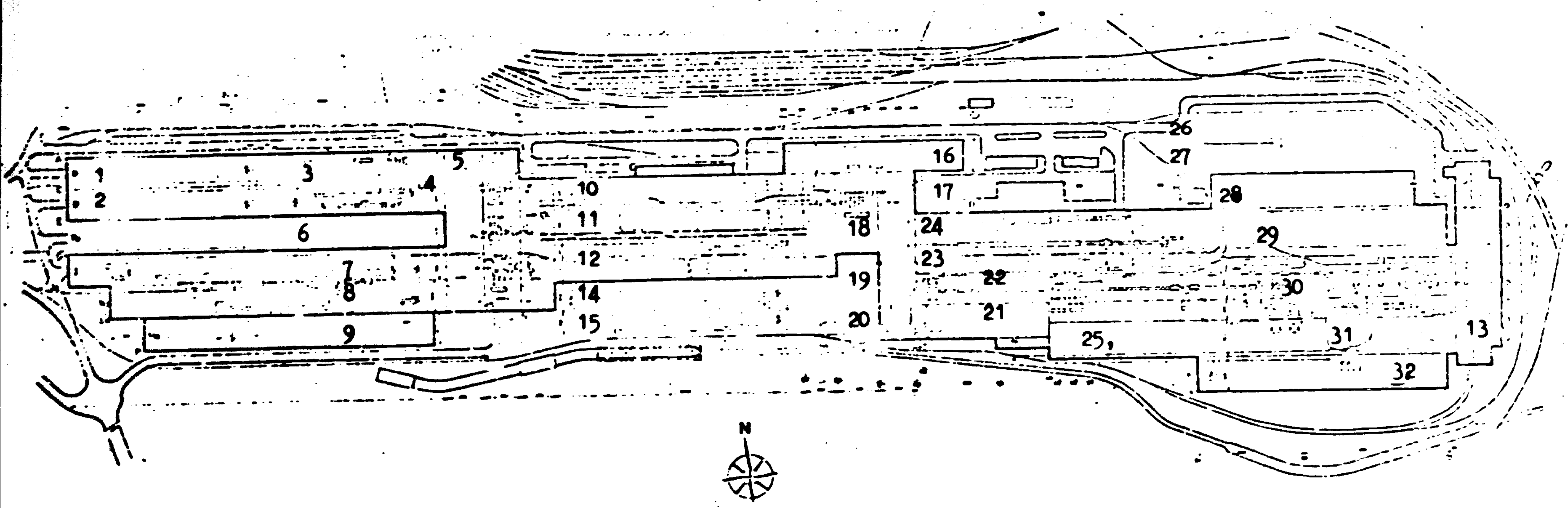


Legend

I. Roughing mill
II. Structural sections mill
III. Plate mill
IV. Hot strip mill (coiler tension strip mill)
A. Motor room for roughing mill
B. South motor room for structural sections mill
C. North motor room for structural sections mill
D. Motor room for plate mill
E. Motor room for hot strip mill
O. Stripping shop
1. Soaking pits
2. Gas compressors for soaking pits
3. Bloom heating furnaces
4. Slab heating furnaces
5. Billet output
6. Sheet bar output
7. Finishing department - sections
8. Finishing department - rails
9. Finishing department - plate
11. Cutting line
13. Fuel oil storage
14. Cooling and filtration centre
15. Slab descaling
16. Oxygen cutting of plates
17. Roller lathes
18. Roller grinders
19. Roller store
20. Guides and guards workshop
21. Rail rolling appliances workshop
22. Transformer station No.1
23. Transformer stations No.2 & 4
24. Transformer station No.3
25. Transformer station No.5
26. Switchgear room D
27. Switchgear room E
28. Switchgear room F
29. Switchgear room G
30. Switchgear room H
31. Switchgear room J
32. Switchgear room No.1
33. Switchgear room No.2

Figure 2

THE ELECTROLYTIC TINNING LINE OF THE NATIONAL STEEL COMPANY OF SPAIN



1. Dispatch
2. Dispatch
3. Plate cutting line
4. Strip cutting line
5. Temper rolling mill
6. Dispatch of galvanised products
7. Galvanizing line
8. Electrolytic line
9. Tinplate dispatch
10. Annealing furnaces - 1
11. Annealing furnaces - 2
12. Electrolytic cleaning line
13. Soaking pits
14. Annealing furnaces - 3
15. Continuous annealing line
16. Roller workshop
17. Four-stand tandem mill
18. Coil store
19. Five-stand tandem mill
20. Pickled coil store
21. Roller workshop
22. Semi-continuous mill
23. Scaling and cropping shop
24. 62" pickling lines
25. Motor room
26. Hot plate dispatch
27. Hot plate cutting line
28. Coil store
29. Semi-continuous mill coil store
30. Roughing mill No.2
31. Bloom store
32. Bloom store

14. The Avilés plant has its own harbour with a 750 m long quay parallel to the inlet, equipped for discharging raw materials, and another quay 265 m long, at right-angles to the first quay, which is intended for the dispatch of finished products.

15. The plant has an extensive internal rail network which is connected to the national railway system.

THE EXPANSION PROGRAMME OF THE NATIONAL STEEL COMPANY OF SPAIN (ENSIDESA)

16. The expansion programme of ENSIDESA, which is now being carried out, covers such major projects as:

- A semi-continuous 68" (1,727 mm) hot rolled strip mill with a capacity of 1,500,000 tonnes per year.
- A second 62" (1,575 mm) pickling line with a theoretical capacity of 964,800 tonnes per year.
- A 40" (1,016 mm) electrolytic cleaning line with a capacity of 150,000 tonnes per year.
- A second battery of annealing furnaces with 27 furnaces and 84 bases, with a production capacity of 432,000 tonnes per year.
- A 2-stand temper rolling mill for 48" (1,219 mm) tinplate, with a production capacity of 187,500 tonnes per year of tinplate.
- A second 60" (1,524 mm) cold rolled plate slitting line with a capacity of 210,000 tonnes per year.
- A 50" (1,270 mm) Armco-Sendzimir galvanizing line with a capacity of 150,000 tonnes per year.
- A 40" (1,016 mm) tinplate coil preparation line with a capacity of 150,000 tonnes per year.
- A 40" (1,016 mm) electrolytic tinning line with a theoretical capacity of 150,000 tonnes per year.
- A 40" (1,016 mm) tinplate classification line operating at a speed of 140/420 feet per minute (43/128 m/minute).

17. It should also be noted that consideration is being given to the installation of a 5-stand tandem tinplate rolling mill which would provide perfect balance between the various installations of the cold rolling plant.

THE MARKET FOR TINPLATE IN SPAIN

18. World production of tinplate increased considerably in the 1960's from about 8,000,000 tonnes in 1960 to approximately 12,300,000 tonnes in 1968: an increase of over 50 per cent.

19. Although tinplate production in Spain is very small compared with that in other more industrialized countries, the increase in tinplate production in recent years has been very considerable, since production increased from 25,000 tonnes in 1960 to 105,000 tonnes in 1968.

20. At the present moment, the tinplate production potential, that is to say, the theoretical national production capacity, is about 152,000 tonnes per year.

21. At the beginning of the 1960's, the situation of the Spanish tinplate market was that there was only a single tinplate manufacturing plant, and this was unable to satisfy the increasing demand from consumers.

22. Tinplate consumption in Spain has increased considerably in recent years, rising from 75,000 tonnes in 1960 to 223,000 tonnes in 1968, so that Spanish national production has not been able to satisfy demand and substantial imports have had to be made.

23. Forecasts of consumption for the coming years (280,000 tonnes in 1970, 325,000 tonnes in 1975 and 375,000 tonnes in 1980, approximately) are considerably greater than national production capacity, and this is the main reason why ENSIDESA decided to install a tinning line which would meet modern technical requirements and reduce this production deficit, thus reducing imports.

24. It is by no means simple to select an installation even when only criteria of profitability are taken into account, and when, in addition, the interests of a national industry as important as the canning industry are considered, the problem becomes really difficult.

25. Until a few years ago, the situation was stationary, and a considerable number of small can manufacturers, using equipment of very low productivity, scraped a meagre existence from a very limited market. The rise in the standard of living and the modernization of installations carried out by some can manufacturers, however, have given rise in recent years to a considerable rise in the production and consumption of tinplate.

26. Even so, however, there are still a large number of small manufacturers with short production runs, making it necessary to manufacture an excessively large number of different shapes and sizes.

27. The fact that tinplate is mainly used in the canning industry and that many internationally known applications which are less sensitive to seasonal influences are still rare in Spain is another unfavourable characteristic of the Spanish market, which is strongly influenced by the seasons of the year.

28. The need to be able to overcome these adverse conditions and to have the capacity to produce the high-quality tinplate needed by modern automatic can-making machines were determining factors in selecting the type of tinning line described in this paper.

29. Obviously, unless we rejected all but purely selfish considerations, we could not take a decision to construct a tinning line solely for the production of a particular type of tinplate: we had to achieve a compromise between such important factors as cost on the one hand and protection of an established industry on the other.

30. It was therefore decided to install a "Ferrostan" tinning line with an annual production capacity of 150,000 tonnes. The United States Blaw-Knox Company was awarded the contract for the construction of the mechanical equipment and the Westinghouse Company was awarded that for the construction of the electrical equipment.

31. As the modern market requires tinplate cut to accurate sizes, it was decided that, as is usual in lines of this type and capacity, the cutting and classification should be carried out on the line itself, but two coiling machines were nevertheless included, in case some can manufacturers decide in future to use coiled tinplate. This possibility also led us to consider installing a P-50 computer to record production data, and this function was later extended (this is an aspect of the plant which is really very interesting in its novelty) to the classification of tinplate and the recording of data when the line produces tinplate cut into sheets.

32. The investment budget for the various installations needed for the manufacture of tin plate covers the following items: modifications to the cooling system of the tandem mill rollers and strip in order to permit the rolling of the thicknesses and qualities required for tinplate manufacture; the electrolytic cleaning line; the two-stand temper rolling mill; the preparation line, and the tinning line. The total investment budget comes to 1,400 million pesetas (20 million dollars), 47 per cent of which will be in foreign currency and 53 per cent in Spanish currency.

33. The installations needed for the manufacture of tinplate, together with the other items in the expansion programme, were ordered in March 1967 (mechanical equipment) and June 1967 (electrical equipment). The civil engineering work and the erection of the building were completed in June 1970 and the production equipment is now being installed, the start-up of the plant being expected to take place in mid-1971.

THE ELECTROLYTIC TINNING LINE

Main features:

34. The ENSIDESA 40" (1,016 mm) electrolytic tinning line is of the "Ferrostan" type, designed by the Aetna-Standard division of the Blaw-Knox Company, with electrical equipment supplied by the Westinghouse Company (figure 3).

35. The line may be considered to form three sections as follows:

- The input or preparation section, comprising the uncoiling, cutting and soldering units.
- The processing section, comprising the pre-tinning, electrolytic tinning, melting, chemical treatment and oiling sections.
- The output or finishing section, comprising the coiling, cutting and classification sections.

36. The line is designed to process cold rolled steel strip between 0.007" (0.178 mm) and 0.020" (0.508 mm) thick and between 18" (457 mm) and 40" (1,016 mm) wide. Both the input and output coils will have an internal diameter of 16½" (419 mm), a maximum external diameter of 72" (1,829 mm) and a maximum weight of 44,000 lbs (19,958 kg). The packages of tinplate will be between 18" (457 mm) and 43½" (1,105 mm) long and have a maximum weight of 12,500 lbs (5,670 kg). The line will operate at speeds of 50 feet per minute (15 m/min) when threading, 270/1,250 feet per minute (82/381 m/min) in the input section and 270/1,000 feet per minute (82/305 m/min) in the processing and output sections.

37. The production capacity of the line, which it is estimated will be 150,000 tonnes per year, will be determined by the thickness and width of the strip to be processed and by the speed of the line, which will depend on the weight of the coating and must keep within limits imposed by the mechanical equipment (1,000 feet per minute), by the maximum current density of 375 amperes per square foot, and by the maximum output of 80,000 amperes which the rectifiers will be able to supply.

38. The length of the line, from the first uncoiling machine in the input section to the last piling machine in the output section, will be approximately 375' $7^5/8$" (about 114 m).

THE INPUT SECTION

39. At the beginning of the input section, the line will have two uncoiling machines so that it can be supplied with strip continuously, a coil being mounted on one uncoiling machine while the preceding coil is being uncoiled on the other. The uncoiling machines will have expanding mandrels whose diameter can be varied from 15½" (394 mm) to 17¼" (438 mm) and will have a table length of 45" (1,143 mm).

40. At the exit from uncoiler No.1 there will be a pinch-roll unit with one pair of rollers and at the exit from uncoiler No.2 there will be another pinch-roll unit with two pairs of rollers: these units will make possible the threading of the strip.

41. Next, a pneumatically-operated double-acting shear will cut the strip.

42. In order to solder the tail-end of one coil to the leading end of the following coil, there will be a Taylor-Windfield limited-overlap welder.

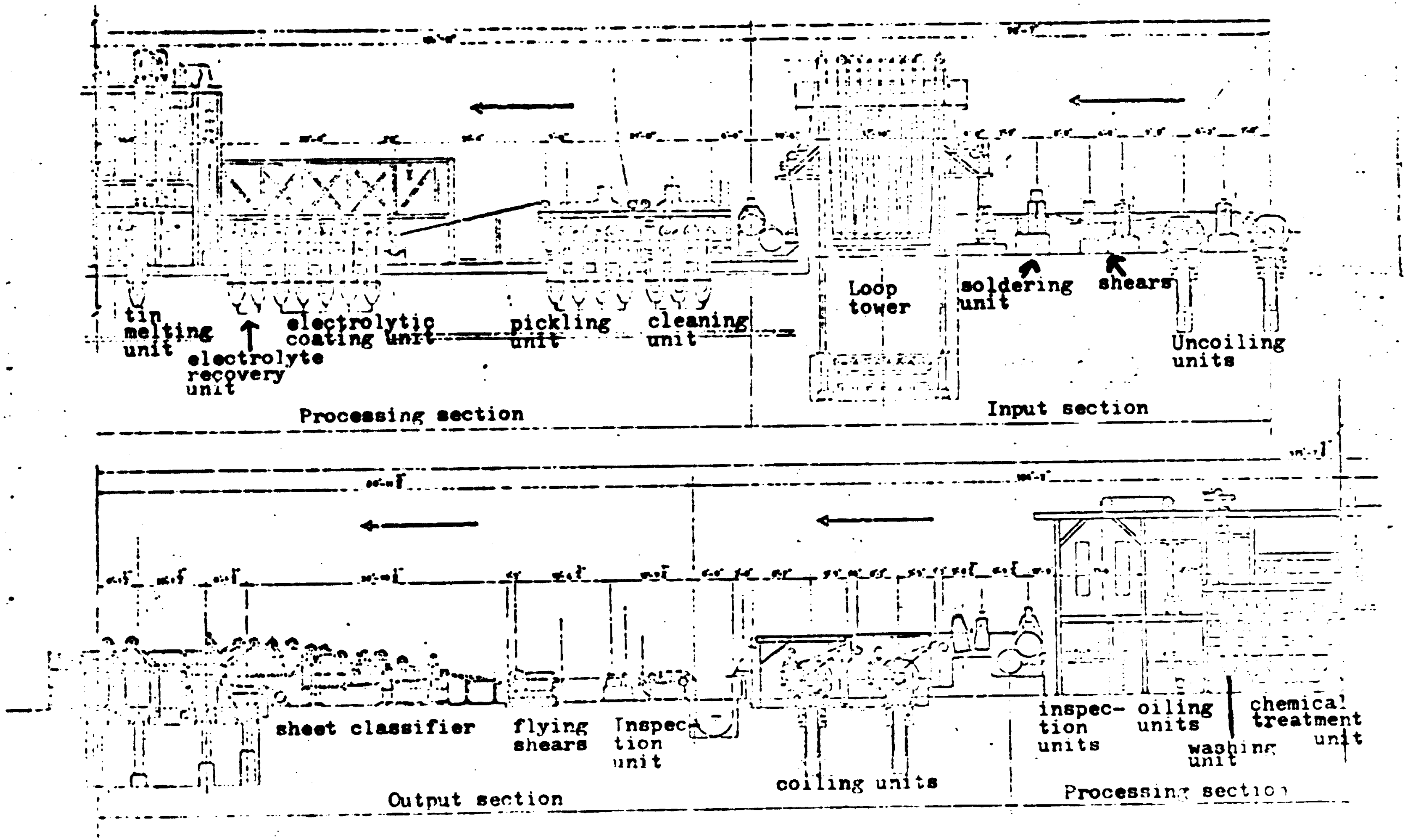
43. The strip next passes through a tensioning unit which draws the strip through the input section and imparts rear tension to the strip in the loop tower.

44. The loop tower, which has an upper set of ten rollers and a lower set of nine rollers, enables the strip to be stored for supply to the processing section when the input section is halted by the need to solder together the ends of the strip from two successive coils. Some 775 feet (236 m) of strip can be stored in the tower. At the entry and exit of the loop tower are stearing rolls actuated by hydraulic equipment controlled by signals from photo-electric cells which monitor the lateral displacement of the strip.

45. At the exist of the loop tower is a second tensioning unit which imparts rear tension to the strip in the processing section.

Figure.3

THE ELECTROLYTIC TINNING LINE OF THE NATIONAL STEEL COMPANY OF SPAIN



THE PROCESSING SECTION

Cleaning unit

46. In order to clean the strip and remove from its surface the oil and dirt deposited on it in previous processes (rolling in the temper rolling mill, processing in the preparation line, and various handling operations in the workshop), the strip will be passed through a bipolar electrolytic cleaning unit. This unit will consist of two tanks in which an alkaline solution is circulated. The strip will pass between electrodes giving opposing charges which will electrolytically intensify the cleaning action of the alkaline solution. The electrodes will be connected to a low voltage unit with a capacity of 4,000 amperes at 24 volts.

47. After cleaning, the strip is subjected to intensive washing with water so as to eliminate from it any remnants of the alkaline solution which the strip might entrain with it and which might contaminate and neutralize the acid in the electrolytic pickling unit. The washing process is carried out by water spray nozzles in a tank similar to those of the electrolytic cleaning unit.

48. The strip next passes between squeegee rollers located over the washing tank to prevent entrainment of water.

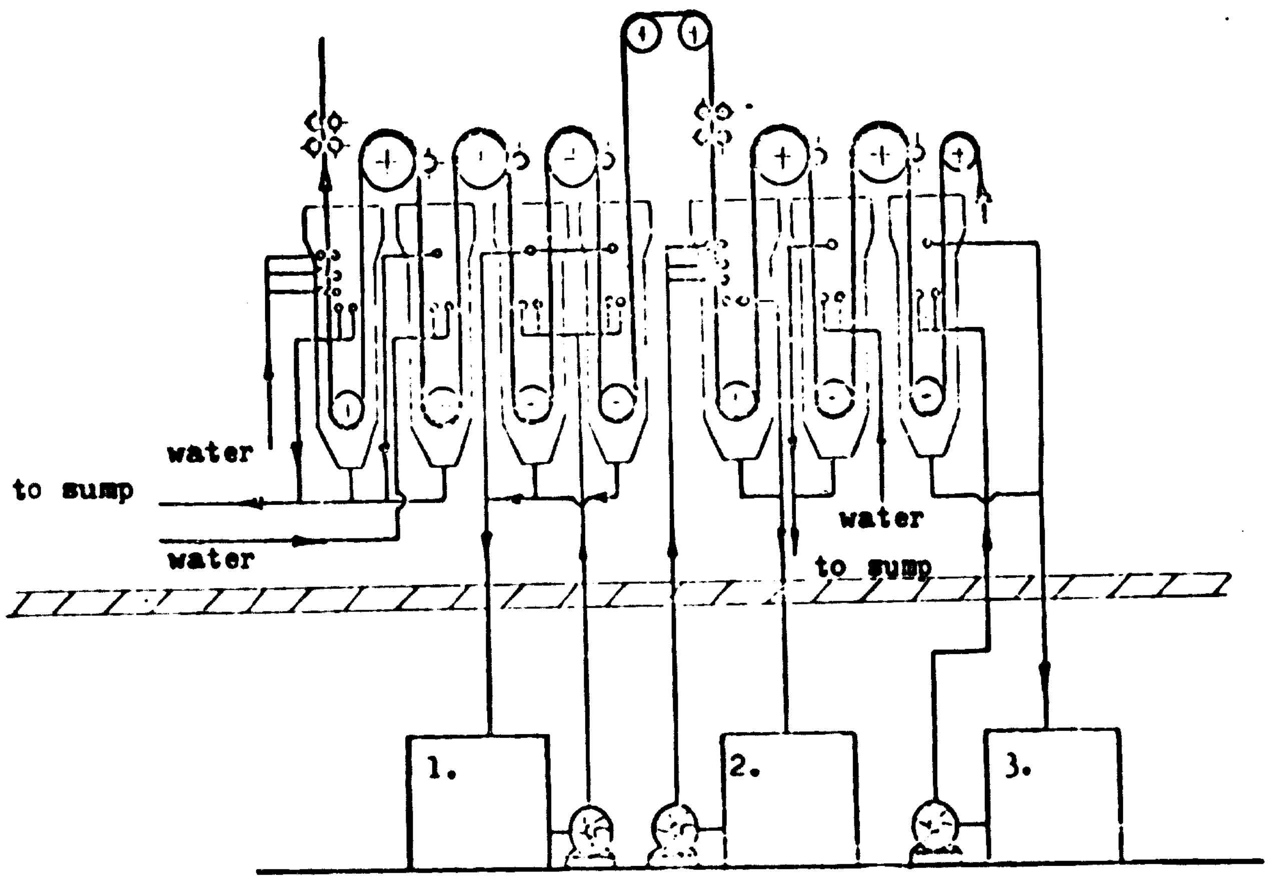
Pickling unit

49. The strip next passes to the electrolytic pickling unit, also of the bipolar type, which consists of two pickling tanks designed to operate with a solution of sulphuric acid and provided with bipolar electrodes connected to two 24-volt units each of 4,000 amperes capacity. Next come two more tanks, one for washing by immersion and the other for spraying with water, where any remnants of the pickling solution which might be entrained on the strip are eliminated. The objective of the pickling process is to eliminate oxides formed in previous processes which have not been eliminated by the alkaline cleaning. As in the case of the alkaline cleaning process, the short space of time available for carrying out this operation makes it necessary to intensify the pickling action of the sulphuric acid by electrolysis in order to secure greater effectiveness. The washing process after pickling is designed to eliminate any pickling solution which might be entrained on the surface of the strip, so as to avoid contamination of the electrolyte in the coating unit.

50. The three above units will have their own appropriate circulation systems, as shown diagramatically in figure 4.

Figure 4

ELECTROLYTIC CLEANING AND PICKLING UNITS



1. 2,000 gallon reservoir for pickling solution
2. 2,000 gallon reservoir for alkaline washing solution
3. 2,000 gallon reservoir for cleaning solution

51. Squeegee rollers located above the spraying tank eliminate any liquid entrained by the strip.

52. An extractor system will be provided to remove fumes from the cleaning and pickling units.

53. When the strip has been cleaned and pickled it passes to the electrolytic coating unit, which will consist of five tanks with rubber-covered rollers running submerged in the lower part of the tanks. In the upper part of the tanks there will be six further pairs of rollers: six tubular copper conductor rollers and six rubber-covered rollers. Each tank will have four points for the suspension of the anodes, which will be connected to low voltage units each of 4,000 amperes capacity at 24 volts d.c., thus giving a total capacity of 80,000 amperes and making possible a maximum current density of 375 amperes per square foot of strip surface. The coating current will be regulated by electronic equipment as a function of the strip speed, the width of the strip and the weight of coating which is desired to obtain. It will be possible to manufacture differentially coated tinplate by altering the number of rectifiers supplying current for each face of the strip.

54. Sufficient space has been left between the electrolytic pickling unit and the electrolytic coating unit for the possible future addition of as many as six tanks if the percentage of heavily-coated tinplate to be produced warrants this or if it is desired to manufacture strip with other coatings, such as "tin free steel". The electrolyte will consist essentially of phenolsulphonic acid, stannous sulphate and ENSA. The phenolsulphonic acid makes the solution highly conductive and avoids oxidation of the stannous ion to the stannic iron. The stannous sulphate initially provides the tin ions in the solution. ENSA is an additive which makes the deposit of tin on the strip more coherent and gives the tin coating greater brilliance during the melting operation.

55. The current passes from the conductor roller in each tank to the strip, so that the strip is the cathode with respect to the tin anodes which are suspended from the anode points in the tinning electrolyte.

56. After the five coating tanks there are two similar tanks for recovering the electrolyte. These tanks have submerged rubber-covered rollers in their lower parts and two pairs of rollers, likewise covered with rubber, in their upper parts.

57. The strip next passes through a squeegee roller unit, which eliminates any traces of electrolyte entrained by the strip, and then through a hot air dryer.

58. The electrolyte circulation and recovery system consists of three circulation reservoirs, three pumps, three heat exchangers for cooling the electrolyte, an evaporator for concentrating the electrolyte and making up for the dilution caused by the recovery liquid, a tank for electrolyte preparation, and two filters for the elimination of slime (see figure 5).

59. When differentially coated tinplate is being manufactured a "Dial-a-Code" marker manufactured by the Pannier Company, located before the melting tower, marks on the strip a number of parallel lines, the distance between which indicates, through a predetermined code, the weight of the coating on each face.

Resistance melting unit (bright finishing)

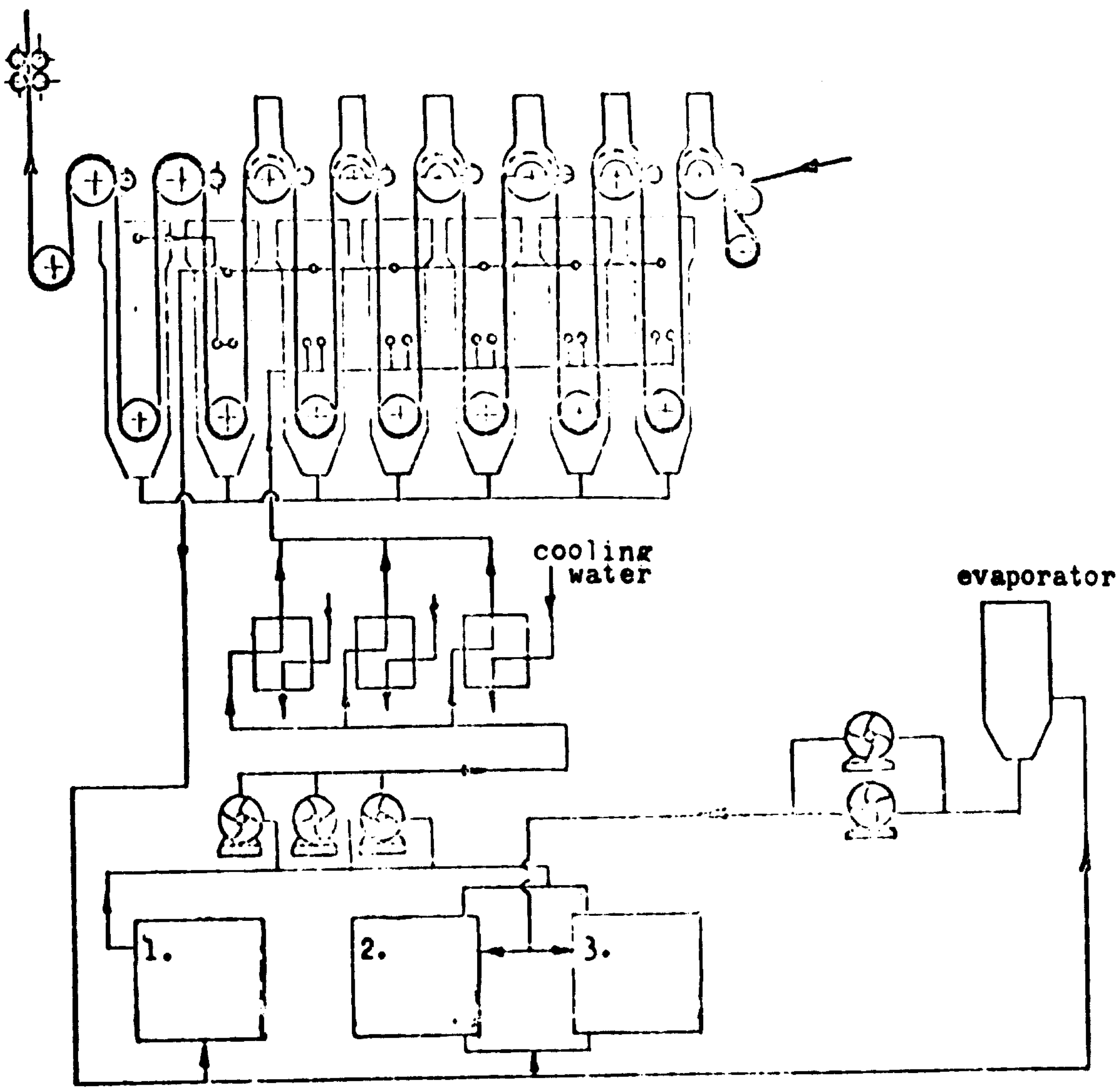
60. The line is next provided with a unit for the resistance melting of the tin coating which consists of two conductor rollers at the lower part of the unit, a supporting roller at the upper part, a heating tower and a cooling tank. The objective of this operation is to make the tin coating bright, for the untreated coating deposited on the strip has a matt, dull appearance. The operation is carried out by heating the strip to above the melting point of tin (232°C) and then rapidly cooling the strip so as to cause the coating to become solid again before it comes into contact with the next roller in the line. The heating of the strip and the melting of the tin coating is effected by passing through the conductor rollers and the strip an alternating current supplied by two 1,250 kVA 6,300/190V single-phase transformers. The loop of strip between the two lower conductor rollers and the support roller passes through an insulated tunnel which reduces heat loss from the strip (figure 6).

61. The two conductor rollers are insulated, while the other rollers are earthed. In order, therefore, to avoid or reduce secondary paths for the current, shock reactors are provided.

62. The melting current is so regulated that the temperature of the strip reaches the melting point of tin slightly before the strip enters the cooling tank. A water circulation system will be provided for the cooling tank.

Figure 5

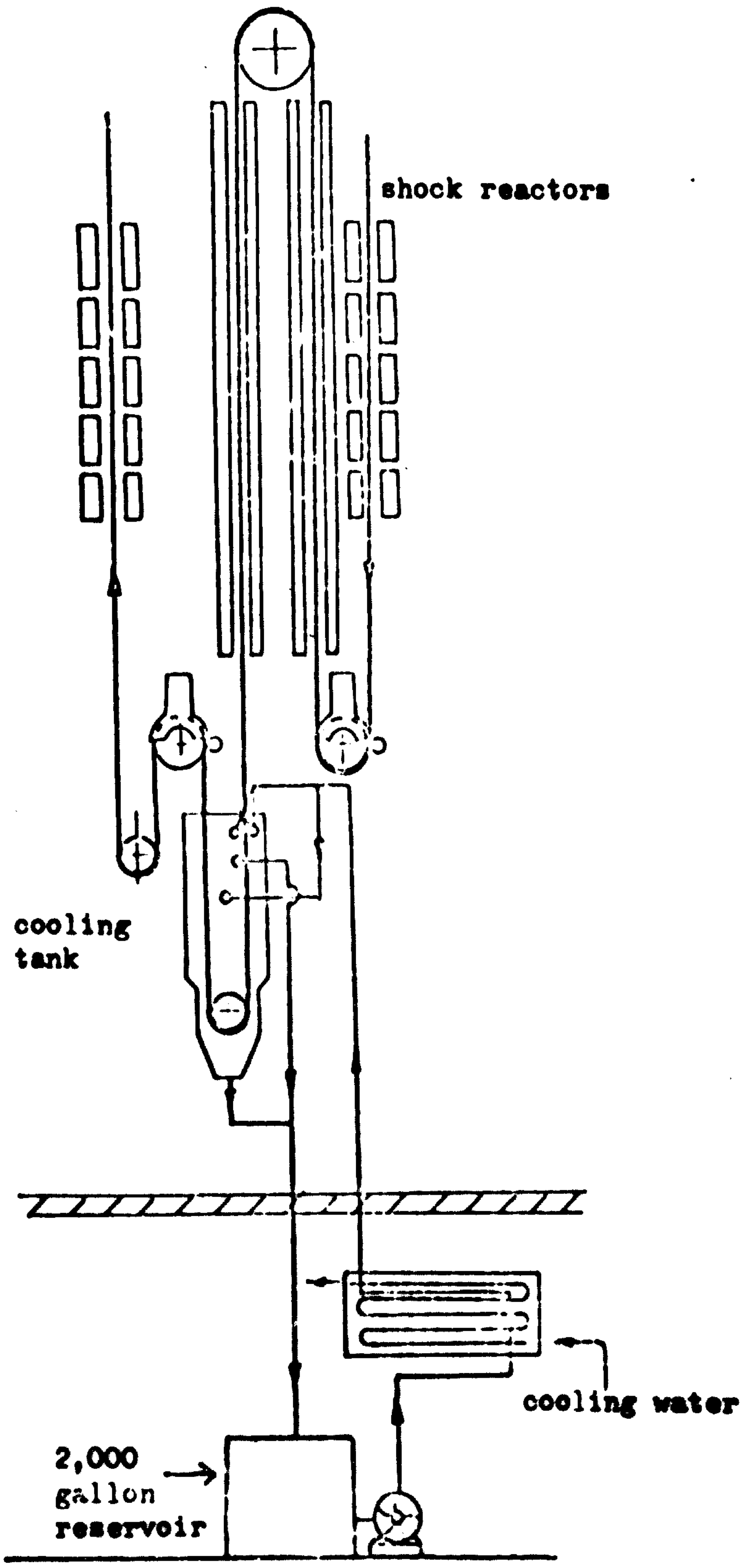
DIAGRAM OF COATING UNIT AND ELECTROLYTE RECOVERY UNIT



1. 9,000 gallon electrolyte circulation reservoir
2. 9,000 gallon electrolyte circulation reservoir
3. 9,000 gallon settling tank

Figure 6

DIAGRAM OF BRIGHTENING (TIN MELTING) UNIT



Chemical treatment unit (passivation)

63. The chemical treatment unit, which is located after the melting unit, is designed to give the surface of the tin the desired characteristics. It will consist of two treatment tanks proper, a tank where the strip is washed by immersion in water, a water spraying tank, two tubular copper conductor rollers and three support rollers (all located in the upper part of the unit) and four other rollers submerged in the lower part of the tank. Each of the two treatment tanks will have four steel anode points (figure 7).

64. The tin coating may become covered with a film of oxide which discolours its surface and gives it a yellowish tinge. This fault usually develops during storage in humid conditions or during baking operations associated with the lacquering or painting of the tinplate. In order to minimize the risk of this fault, chemical treatment is given with the object of stabilizing the surface of the tinplate by chemical or electro-chemical means, the type of treatment given depending on the degree of stability of the oxides produced and the application to which the tinplate is to be put.

65. The treatment is carried out by submerging the strip in an oxidizing solution which forms a thin, even protective film on the surface of the tinplate.

66. Depending on the type of solution and treatment used, the oxidizing action can be intensified electrolytically. For this purpose two low-voltage units are available: one supplying 4,000 amperes at 24 volts and the other 500 amperes at 8 volts. The first unit is used for cathodic treatment in the first tank, while the second is used for anodic treatment in the second tank.

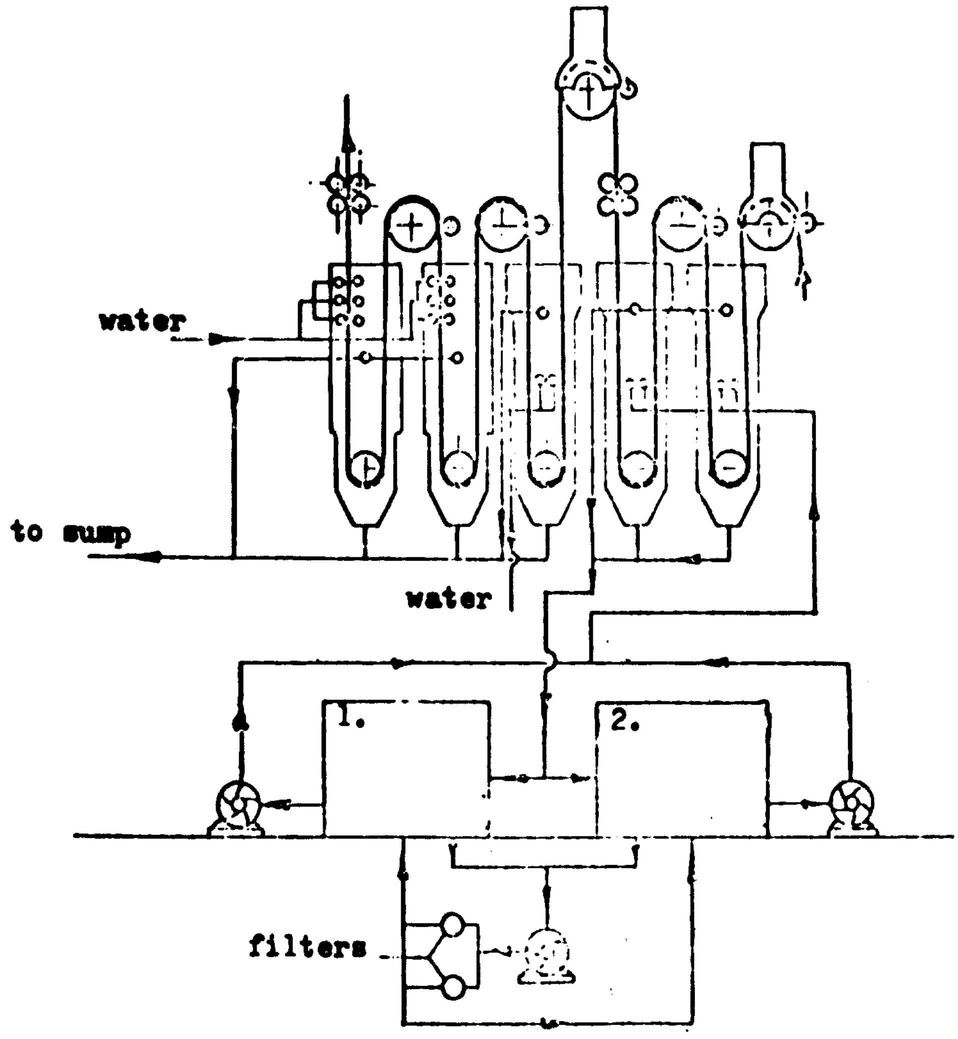
67. The chemical treatment unit is designed to carry out various types of treatment, according to the uses to which the tinplate is to be put. The most frequently used treatment is cathodic-anodic treatment in a solution of sodium dichromate.

68. After undergoing the chemical treatment in the first two tanks, the strip passes between squeegee rollers before entering the immersion washing tank, in order to reduce the amount of solution entrained on it.

69. A system of reservoirs, pumps and filters, shown diagramatically in figure 7, will be provided for the circulation of the chemical treatment solution.

Figure 7

DIAGRAM OF CHEMICAL TREATMENT UNIT



1. 3,000 gallon reservoir for chemical treatment solution
2. 3,000 gallon reservoir for chemical treatment solution

70. After the chemical treatment, the strip is washed in tank 3 (immersion washing) and tank 4 (water spraying) of the chemical treatment unit. The washing process is designed to eliminate from the surface of the tin the soluble chemicals and slime entrained by the strip.

71. The washing process (washing by immersion and water spraying) is continued in a tank of the washing unit after the chemical treatment unit.

72. The strip then passes between squeegee rollers to reduce the amount of liquid entrained by it.

73. The line is next equipped with a steam drier which washes and heats the strip and a hot air drier which completely dries the tinned surface before the strip is oiled. A system of steam extraction is provided to eliminate the steam released in the steam drying process.

Oiling unit

74. The drying units are followed by a "Trion" electrostatic oiler (figure 8) which is designed to deposit on the tin coating 0.05 to 0.50 grams per base box of cottonseed oil or dioctyl sebacate. The potential needed to attract the ionized particles of oil to the strip will be 40,000 volts.

75. The object of the oiling process is to apply a fine film of lubricating oil in order to protect the tin coating against abrasion, thus minimizing subsequent damage in handling, facilitating sorting and handling, and helping in the operations of lacquering and printing the tinplate.

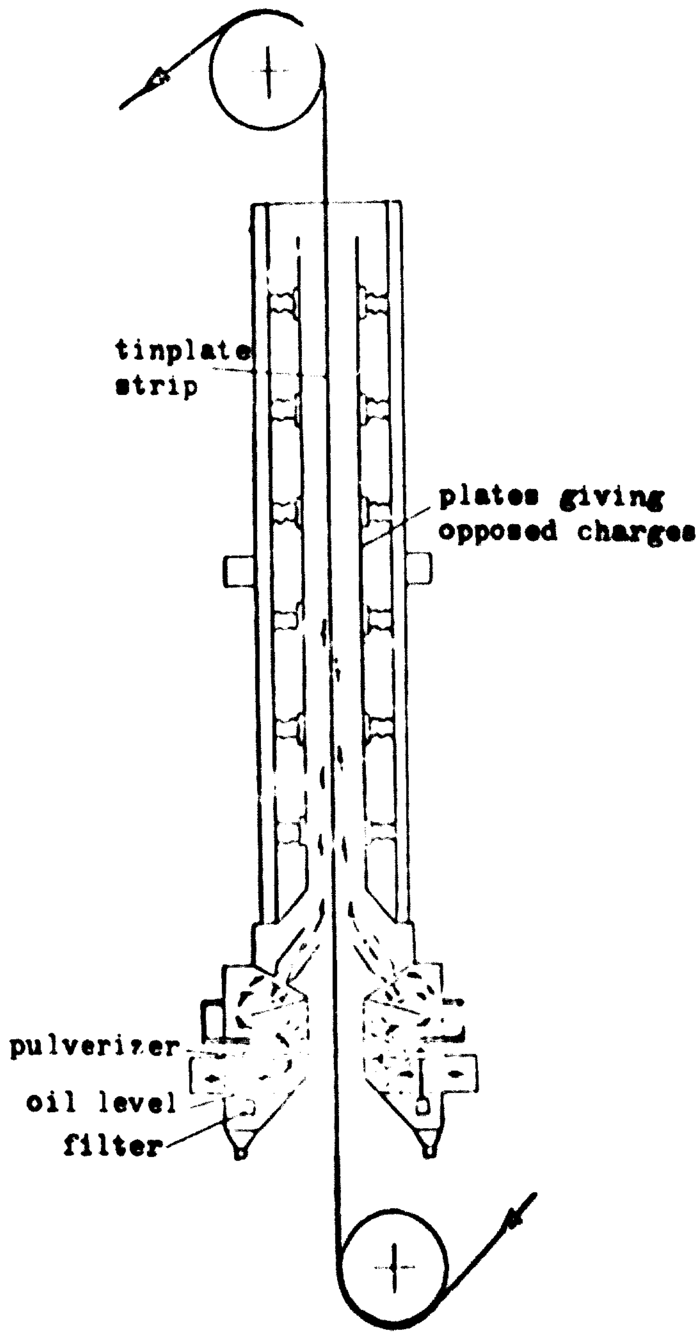
76. Once the tinplate has been oiled, all the phases of the manufacturing process proper can be considered to be completed.

77. The next unit in the line after the oiler is inspection station No.1, which is provided with equipment for visual inspection of the strip (Scan-a-Web system) consisting of a cabin with mirrors and lights which enable both faces of the tinned strip to be inspected at the normal operating speed of the line and a console with ten buttons (corresponding to the various types of defects which there may be) which transmit signals to the computer (described below).

78. Next, before tensioning unit No.3, comes a series of measuring instruments consisting of equipment for measuring the thickness of the strip by X-rays and equipment for detecting holes in the strip. Both these sets of equipment are connected to the computer.

Figure 8

DIAGRAM OF ELECTROSTATIC OILER



79. Tensioning unit No.3 imparts to the strip the traction necessary to draw it through the processing section of the line.

THE OUTPUT SECTION

80. The strip is next fed towards the coiling machines through a set of traction rollers, a shearing unit capable of cutting the strip while it is moving at a maximum speed of 350/400 feet per minute, and "Askania" lateral control units which make possible proper coiling of the strip.

81. The coilers will be of the expanding mandrel type, with hydraulic control of transverse movement and elevation and automatic aligning equipment.

82. The reels of tinplate formed on the coilers can be removed from the line on unloading skids and sold in the form of coils if the market so permits, or else they can be sent on down the line for cutting into sheets as described below.

83. After the coilers, in order to enable the strip to be put through the cutting and sorting processes, there is a loop pit with retractable table equipment to facilitate threading.

84. Inspection station No.2 is located after the loop pit and consists of a strip thickness measuring device and two hole detectors and markers, all connected up to the computer.

85. Next, the strip passes on, via a roller machine, to a Halldon rotating flying shear. The shear is synchronized to cut sheets from 18" (457 mm) to 43½" (1,105 mm) long with a cutting tolerance of ± 1/32" (0.79 mm) at a maximum cutting speed of 1,000 feet per minute.

86. On emerging from the shearing machine, the sheets pass to a Kaufman four-stack sheet sorter, designed to receive, sort and direct the tinplate to a reject stacker (sheets with holes or of the wrong thickness), a "menders" stacker, and two stackers for first quality sheets. The stackers will be hydraulically operated and will have pneumatically-operated package discharge devices.

87. The sheet sorter will be designed to operate at a speed of 1,000 feet per minute and will have four transporters and three pairs of magnetic rollers so that the sheets can be transported to the appropriate stacking units by means of the computerised control and classification system described below.

88. The packages of sheets will be removed from the line by the unloading mechanisms of the sheet sorter and will pass to the manual packing section, from which they will be sent to their final destination in the sheet store.

89. The line will be driven by variable-voltage motors supplied from controlled dirode rectifiers. The current for the pickling, electrolytic cleaning, and chemcial treatment tanks and for the anode points will be supplied by silicon rectifiers.

THE PROCESS COMPUTER

90. The Westinghouse P-50 computer which to a certain extent controls the line deserves a separate chapter because of the novelty of some of its functions. For greater clarity, we shall describe each of these functions separately.

Recording data on the production of coils of tinplate

91. An impulse generator coupled to a roller in the centre section will send a signal to the computer for every 250 mm of strip which passes over it, thus generating a scale of measurement. We shall refer below to these 250 mm sections of strip as "elements".

92. Every defect detected between two successive impulses is notified to the computer by means of the signals sent from the visual inspection, X-ray measurement or hole detector points and assigned to the corresponding element of the strip, and a signal is also sent to the shearing machine, so that when the strip element in question passes through the shears the total number of defects and the total number of each particular type of defect will be calculated and marked. With this procedure, the signals subsequently given by the computer refer only to the strip which has emerged from the line, and not to the strip which is still within it. Obviously, even when an element contains several defects it is only counted once in the calculation of total defects, and the same applies to the calculation of the total number of each particular type of defect.

93. The functions carried out by the computer in this respect under normal operating conditions may be summarized as follows:

- Measurement of the length of strip coiled.

- Recording and totalling the number of elements containing defects.

- Continuous determination of the total percentage of defective elements and of the percentages of elements containing each particular type of defect, an alarm signal being given if any of these percentages exceeds a predetermined value.

- Display on a luminous panel (brought up to date every two seconds) of the percentage of non-defective elements processed.

- Display on a luminous panel of the length of strip coiled up to the moment.

- Slowing down of the line (or, optionally, giving of an alarm indicating that the line should be slowed down) when a predetermined number of metres of strip remain to be processed in order to complete a predetermined total length of strip.

- Automatic printing, every time that the shears operate, of a report containing the following information:

  Date

  Time

  Number or numbers of the input coil or coils used to produce the coil of finsihed product

  Number of the ccil of finished product

  Width of strip

  Thickness of strip

  Weight of coating

  Total length of coil

  Weight of coil

  Length of first quality strip

  Weight of first quality strip

  Percentage of first quality elements

  Percentage of elements with holes

  Percentage of elements greater than the permitted thickness

  Percentage of elements of less than the permitted thickness

  Percentage of elements with each particular type of visual defects (up to ten defects).

94. When all the coils for a particular order have been processed and the operator at the data input console changes the order number, the strip dimensions or the type of coating, a report is automatically printed with the following information:

Date

Time

Order number

Width of strip

Thickness of strip

Weight of coating

Number of coils in order

Number of coils of scrap produced

Total length of useful strip in the order

Total useful weight of the order

Total length including scrap

Total weight including scrap

Length of first quality strip

Weight of first quality strip

Percentage of first quality elements

Percentage of elements with holes

Percentage of elements greater than the permitted thickness

Percentage of elements of less than the permitted thickness

Percentage of elements with each particular type of visual defects (up to ten defects).

95. The variable data must be introduced manually by the operator at the data input console, who can also determine that a particular coil shall be counted as scrap.

Sorting of sheets and recording of data

96. We believe that this function of the computer represents a real novelty, as we are not aware of any other line where the sorting is carried out by a computer.

97. What may be called the peripheral equipment, that is to say, the equipment other than the computer, consists of the following items:

- Instrument unit No.2, located before the flying shears, which consists, as already stated, of an X-ray thickness gauge, two hole detectors, and two markers for placing marks on the sheets to indicate that they contain this type of defect.

- An impulse generator, coupled to one of the rollers of the flying shears, which sends a signal to the computer for every 25 mm of strip which passes.

- Five photo-electric detectors, three of them located before the magnetic rollers which form the entry section of the stacking machines and the other two located over the exit transporter of the rotary cutter for the purpose of detecting gaps which may be caused when the operator removes a sheet from the transporter.
- Three consoles with data input facilities and liminous panels to display the number of sheets in the corresponding stacking machine.

98. The computer records the defective elements in a similar manner to the way in which defective elements in coils of strip are recorded (it should be noted that here the elements are only 25 mm long) and it signals the position of the defective elements to the flying shears. When the flying shears make a cut, they send the computer a signal which sets in motion a programme examining all the elements which have passed the shears since the previous cut. It is thus determined whether the sheet which has just been cut is of first quality or if it is a "mender" or reject sheet because it has defects. The classification thus made is then stored in the computer's memory until the right moment.

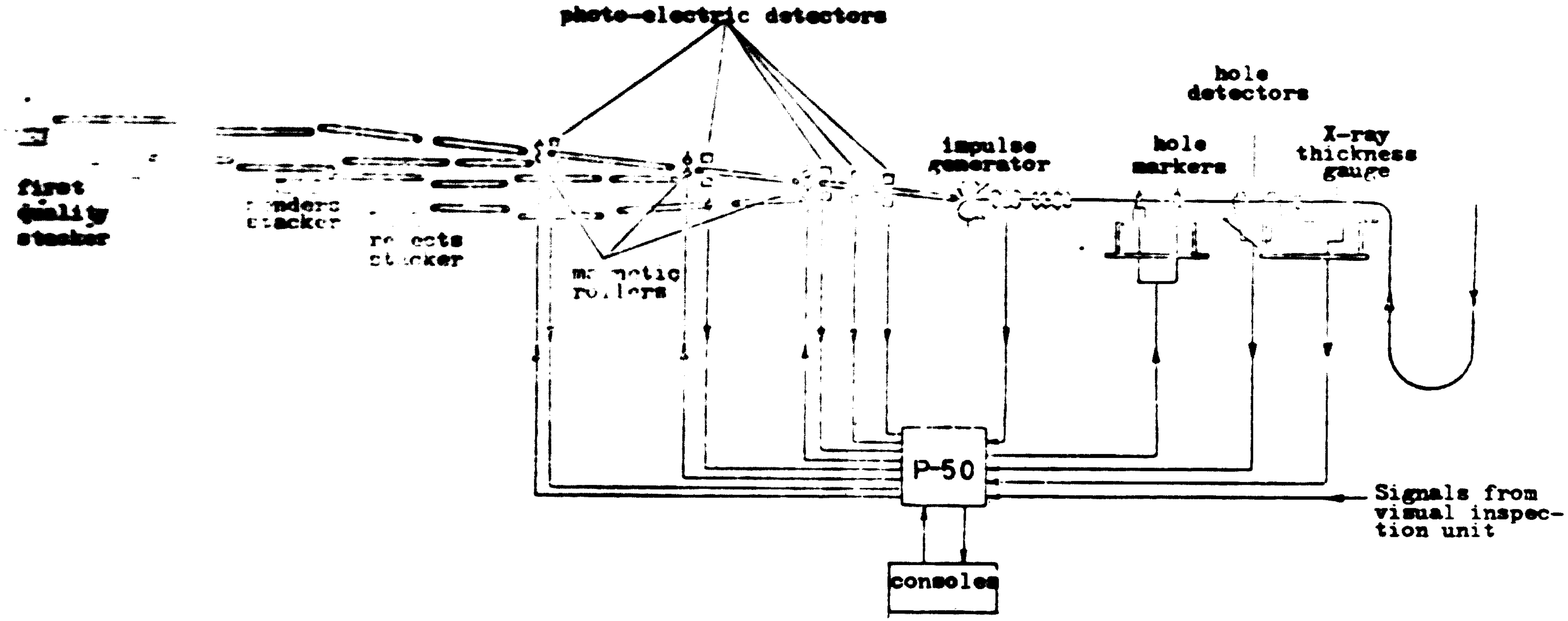
99. Obviously, although the elements are only 25 mm long, the cut will generally come within them rather than exactly at their edges. If the element in question is defective, it is impossible to say which of the two sheets sharing that element is defective, and the solution, as in the conventional "single sheet classifier" systems, is to take it that both sheets are defective.

100. When a sheet arrives at the entry to a stacking machine, the photo-electric detector sends a signal to the computer, which consults its memory to find out what classification it had previously allotted to the sheet in question and to determine to which stacking machine sheets of that classification should be sent. The computer then immediately decides whether or not a signal to change the state of the magnetic rollers must be sent, and, if necessary, sends such a signal. If the sheet is to stay in the stacking machine where it is at present located, no further routing is necessary; if not, it continues on to the next detector, where the operation is repeated.

101. The above-described procedure enables operations to be carried on and information to be obtained with a degree of speed and efficiency difficult to achieve with one of the conventional systems.

Figure 9

DIAGRAM OF SHEET CLASSIFIER AND ITS CONTROL SYSTEM



102. In normal operation, with the four stacking machines in service, one of them - the first machine in the direction in which the sheets are travelling - will be used for sheets which have holes in them or which are of the wrong thickness, the second will be used for sheets with visual defects, and the other two for first quality sheets.

103. The operator pre-selects on the console of one of the first quality stacking machines the number of sheets which the package which it is desired to form is to have. The sheets without defects will then be directed to the selected stacking machine and the number of sheets stacked at each moment will be displayed on a luminous panel. When the desired number has been reached, the sheets will automatically be directed to the other stacking machine, where the operator will likewise have previously selected the number of sheets which the new package is to have. When this package is completed, the sheets are directed once again to the first stacking machine, from which the previous package will have been removed, and the cycle is repeated.

104. If one stacking machine were out of action the process could still be carried on in the same way simply by putting all the rejects, whether for visual defects or other reasons, in the same stack.

105. Even with two stacking machines out of action the line can still function by sending first quality sheets to the reject stack during the time taken to remove the completed packages.

106. The percentages of defective sheets are continuously calculated, and if they exceed certain predetermined limits the corresponding alarm is operated.

107. The percentage of first quality sheets is displayed on a luminous panel which is brought up to date every two seconds.

108. When a package is completed, the computer causes a report to be printed with the following information in it:

Date

Time

Shift

Order number

Package number

Width of sheet

Thickness

Weight of coating

Length of sheets

Number of sheets in the package

Weight of package

109. When an order for sheets is completed, report is printed with the following information, just as in the case of an order for coiled strip:

Date

Time

Shift

Order number

Width of sheet

Thickness

Weight of coating

Length of sheets

Number of first package in the order

Total number of packages in the order

Total number of sheets in the order

Total weight of the order

Total number of sheets

Total number of first quality sheets

Total weight

Percentage of first quality sheets

Percentage of sheets with holes

Percentage of sheets greater than the permitted thickness

Percentage of sheets of less than the permitted thickness

Percentage of sheets with each particular type of visual defect (up to ten defects).

110. At the end of each shift, or at any desired moment, a report is printed with the following information:

Date

Time

Shift

Total number of coils produced

Total number of sheets produced

Total number of coils for scrap
Total length of strip coiled
Total length of strip cut
Total weight of strip coiled
Total weight of strip cut
Length of first-quality strip in coils
Number of first-quality sheets
Total number of packages
Total weight of first-quality sheets
Total weight of first-quality coiled tinplate
Percentage of first quality strip coiled
Percentage of first-quality sheet
Percentage of coiled strip with holes
Percentage of sheets with holes
Percentage of strip of incorrect thickness
Percentage of sheets with visual defects
Percentage of strip with visual defects

111. A daily report of the same layout is also printed summarizing the results of the three shifts worked.

Following the soldered joints through the line

112. It is considered that it would be helpful to the operators to know when a soldered joint arrives at certain points in the line. In order to achieve this, the computer will record the moment at which the soldering operation is carried out and it will then follow the course of the soldered joint through the line, indicating when the joint arrives at a predetermined distance from the coating tanks, the melting tower, the flying shears and the rotary cutter. The progress of the joints is indicated by lights which come on when the joints pass certain points and go out when the joints leave the section concerned.

113. As the amount of strip stored in the loop tower varies and it is necessary for the computer to know this in order to carry out this function, there will be another impulse generator located before the loop tower which will send a signal for every 250 mm of strip which passes it and thus, in conjunction with the impulse generator in the centre section, enable the length in question to be determined. Furthermore,

in order to avoid the accumulation of errors due to slipping on the rollers, etc., the number representing the length of strip in the loop tower will be corrected each time that the lower set of rollers passes a predetermined position, where a switch will be operated.

114. Although at the moment only the soldered joints actually made in the line itself will be followed, it is also possible to follow those which may exist in the strip from the input coils. All that would be necessary would be to add another soldered joint detector.

115. This function of the computer will enable process data to be recorded starting from the input coils, thus making it possible to establish the correlation between the quality or yield of the finished product and the raw material used for its manufacture. Every time a soldered joint passes the shears, a report will automatically be printed with the following information:

Date
Time
Shift
Order number
Number of input coil
Width of strip
Thickness of strip
Weight of coating
Length of coil
Weight of coil
Total length of first quality strip
Percentage of first quality elements
Percentage of elements with holes
Percentage of elements greater than the permitted thickness
Percentage of elements of less than the permitted thickness
Percentage of visual defects of each type (up to ten defects).

Recording data on stoppages and alarms

116. Each stoppage in the centre section is detected by the computer, which then demands, by means of a light signal, that the operator shall feed into the input console a code explaining the reason for the stoppage. A daily report will be printed giving the number and times of the stoppages due to each of the reasons contained in the code.

117. Every one of 300 points on the line and the auxiliary equipment will be examined periodically by the computer to verify whether it is operating normally or not, and an alarm will be actuated whenever any abnormality is detected at any of the points. The return to normal operation will also be recorded and printed.

118. These records will consist of the following information:

Time at which the abnormality occurred or ceased.

Numerical code indicating in which of the following seven categories the abnormality occurred:

1. Input section operation.
2. Centre section operation.
3. Output section operation.
4. Stacking machines and sorter drive operation.
5. Auxiliary alternating current items.
6. Rectifiers and tin melting system.
7. Variable voltage and auxiliary items (helpers).

Key indicating the importance of the abnormality

Code corresponding to the point at which the abnormality took place.

119. It will also be possible, whenever desired by the operator, to obtain a report showing all the points which are in an "abnormal" state of operation at any given moment.

SUMMARY

120. ENSIDESA's 40" (1,016 mm) electrolytic tinning line, which is now being erected and is expected to be started up about the middle of 1971, will represent a great step forward in Spanish production of tinplate and will enable imports of this material to be reduced.

121. From the technical point of view, it should be noted that the line will be equipped with a process computer for the classification of sheets and for recording data on the process and the products obtained.

122. Provision has been made for modification of the line to increase its production capacity and for variation of the types of coatings supplied. In addition, provision has been made for the possibility of installing a second line in the same shop if demand for tinplate increases at the expected rate and circumstances make such a second line desirable.

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