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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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MAINTENANCE AND REPAIR OF ROADWAY EQUIPMENT

by

P. Cordiner
Richmond Car Store Co.
Warrington, United Kingdom

Organized in co-operation with the German Foundation for Developing Countries and the Association of German Machinery Manufacturers (VDMA)

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MAINTENANCE AND REPAIR OF FOUNDRY EQUIPMENT

When I was invited to write this paper I decided that the best way to cover this vast subject was to treat it as a case history after once setting before you my objectives.

The main objective of any engineer must surely be to provide a smooth running plant and an efficient department. This in itself calls for:

1. an organised department,
2. a good, well-trained and contented staff,
3. sufficient spare parts to meet the needs,
4. readily available information, drawings, and correct equipment to tackle any job.

My second objective is to try and show, both, when and how each item of equipment should be maintained or repaired.

My final objective is to endeavour to impress on other engineers, the importance of our responsibility to keep up with the times, with new developments, new equipment, new materials and most important of all, our responsibility to always treat our work as a challenge, for there is always a way to improve our efficiency.

INTRODUCTION

The Company to which I belong is Richmonds Gas Stove Company Ltd. who are manufacturers of a well known range of domestic gas cooking appliances ("NEW WORLD").

In the foundry we have installed a modern automatic foundry plant supplied by Badische Maschinenfabrik. This plant in total has cost almost £500,000 which includes civil costs and also £40,000 for spares. It consists of an automatic moulding section

of the high pressure jolt/squeeze type, two copes and two drags being moulded simultaneously and it is of the box through feed type. The plant has a production output of around 260 boxes per hour, box size being 350 x 550 x 150/150 m.

The moulding machine, box handling equipment, box clamping and declamping arrangements, the twin punch out unit, trash unit and index conveyor drive clamp all require hydraulic motive power which is supplied by five constant delivery, fixed angle, axial piston pumps to a pressure of 100 Kg/cm^2 and delivery of 150 litres per minute per pump, also for high pressure squeeze one constant delivery, 6 port, radial piston pump, up to 200 Kg/cm^2 and delivery of 45 litres per minute. At the present moment the working fluid is a water in oil emulsion at a 40/60 ratio, this being supplied in order to obtain some degree of fire resistance. This hydraulic power is distributed by means of solenoid operated spool valves, all of which can be manually over-ridden if so required.

The moulding boxes are transported from one section to another on an indexing pallet conveyor, which takes approximately 5 seconds to index and then waits approximately 9½ seconds for the next cycle to commence.

After each moulded box is punched out, the castings, together with the sand, are vibrated on four consecutive vibrating chutes so that the castings are finally delivered on to a slat conveyor, relatively free from sand or cores. The sand and broken down cores having fallen through holes in the chutes onto rubber belt conveyors to return into the sand preparation system.

The sand conditioning plant is a fairly typical one consisting of 31 rubber belt feeding conveyors, 4 bucket elevators, 2 magnetic separators, a double shaft mixer, one rotating screen, 2 sand mullers and one sand disintegrator (aerator).

The whole sand system is automatically interlocked to the moulding plant to prevent blockages etc. The sand required by the moulding plant being in the region of 60/70 cubic metres per hour. To deliver this the two mullers are both capable of conditioning 50 m^3/hr. and the sand is kept constant in the automatic sequence by mouldability controllers. The additives required in the sand are supplied to the mullers in measured quantities from small stock bins, these being filled from large silos outside the foundry by means of a pneumatic conveying system. This system involves a transmission of powder over 350' (110m) including an elevation of 60' (18m).

The molten metal is supplied to the plant from one of two cupolas each having a nominal output of 6 tons per hour, it then passes through a continual slagging box and on into a hot metal receiver of the "holding" type. From the receiver spout metal is collected by four, 6 cwt. (300 Kg) geared ladles, each being suspended by wire ropes from 1 ton hoists having both hoist and traverse motors.

The whole system is kept relatively dust free by means of 2 wet type dust extraction units rated at 760 m^3/min. air rate, with 320 mm. W.G. powered by 100 h.p. electric motors, electrolytically started, slip ring type, a 20 h.p. system over the pouring section and also a 15 h.p. fresh air blower.

The electrical supply and control is basically in three separate sections:-

1) Sand plant control cabinet, consisting of a 650 amp main breaker, fused isolators, relays, contactors, printisters, all equipment being of a conventional nature.

2) Sand plant operational panel which allows the whole system or any part of it to be operated in either automatic or manual. It also contains adjustments for change in sand condition or rate of sand flow. The front of this panel displays a mimic sequence diagram.

3) Moulding plant control cabinet, containing in one half the conventional equipment, 1000 amp main breaker, fused isolators, relays, contactors, magnet switches, transformers for pattern heating, solenoid voltages etc. and rectifiers. The other half contains the main brain of the automatic plant which consists of 2,500 solid state (static) switching and controlling modules, power packs, transformers, level controllers, etc. (all supplied by Telemechanique Electrique). On the front of this control cabinet, overlooking the main operating area is a mimic diagram consisting of lamps which give the instantaneous situation for any item of plant in signal form.

There is also a main operating panel and three small ones at the outlying parts of the plant, for carrying out all manual functions and normal operating buttons.

This plant produces on a 5-day week basis commencing at 6.00 a.m. and terminating at 9.50 p.m. - included in this are two 30 min. break periods and a 20 min. change-over period. During these three intervals we exchange pattern plates and when

possible carry out a little maintenance.

We actually start the plant at 5.15 a.m. and close down at 10.15 p.m., this allowing an actual maintenance period of 6½ hrs. per night.

OBJECTIVE 1

Part 1 - An Organised Department

For any maintenance department to function efficiently some form of planned maintenance scheme must be used. This term - planned maintenance - is many times misunderstood and the thought discarded because it seems to conjure up visions of teams of personnel, planning, drawing up sheets and graphs, filling in cards and sheets, logging and filing. Of course, few things in life are easy and it is wrong to think that it is just so in running such a scheme, however, I intend to point out by quoting my own system that it is not too difficult nor complex.

Firstly, let us understand that no two plants are alike due to age, type, size, complexity and personnel. This means that every engineer, manager or foreman must be flexible in his ideas and draw up a scheme suitable to his own situation.

My own scheme is a combination of the following:-

a) Planned lubrication on a rota system (Fig.1) carried out by a man on permanent night turn and signed by him periodically. This work should be so planned that his job is easy, requiring little thought other than to meticulously carry out his duties by following his written sheets. In our case he receives a list of items requiring nightly, weekly, two-weekly, monthly and six-monthly lubrication. He also has a list which is based

OBJECTIVE 1 (contd.)

upon a two-weekly set of sheets to show him the most economic way to carry out his work, i.e. a route sheet.

Besides these he has a detailed list of oils and greases showing which are applicable to each item of plant. NOTE! This man is important to you - try to make him meticulous, conscientious and clean.

b) Planned inspection sheets (Fig.2) These are issued to the skilled fitter/technicians who tick off each item as inspected during each separate shift, whether it be a production shift or the maintenance shift. He is also given a guide sheet (Fig.3) showing some of the other items that require special attention. When possible, faults should be corrected immediately, hence he should take with him a small tool box or a few adjustable tools, etc. On his rounds he also double checks the unskilled greaser for gearbox oil levels etc.

c) A signed Log book to enable us to change shifts efficiently. This details work carried out or required to be carried out, special notes, points to watch, etc.

d) Planned Preventive & Planned Running Maintenance. Weekly Job Sheets (Fig.4) are made out so that all jobs due to be carried out can be done so with forethought and planning. Any jobs not carried out during that weekly period can then be easily brought forward onto the next week's sheets, thus obviating any work getting forgotten. Should the list begin to increase beyond possibility then overtime must be organised to correct it or on the other hand your staff size may require a re-appraisal.

OBJECTIVE 1 (contd.)

On the same sheet the technician fills in details of the work completed, any special remarks and an approximate job time for use in further job planning.

e) Planned Corrective Maintenance

Whenever a breakdown does occur during production time, spare parts must be available and equipment ready to enable the plant to be restored to a working condition as quickly as possible.

Note! We have no permanent storekeeper therefore all spares are available to the skilled men at any time. These breakdowns must be booked on their weekly sheets in order to form a permanent record for use in future analysis.

f) Materials Cards are supplied and handed in weekly by the technicians; on these they enter all materials taken from stores, when used and upon which item of equipment.

g) When the three sets of information have been collected, I with the aid of my assistants and a female clerk/secretary am able to:-

1) Check all work completed and enter on a record card (Fig.5).
2) Note all work still not completed, all work requested after inspection and enter these, together with the next week's jobs on new weekly job sheets marking any work to be treated as a priority.
3) Forward reasonably accurate maintenance costs to our costing department.
4) Correct the plant stock cards with regard to all items used, and re-order whenever the stated minimum stock quantities are reached.

OBJECTIVE 1 (contd.)

Note! The information about each week's work is basically obtained from Maintenance Schedule Cards (or Job Cards) (Fig. 6), these list all work required on each item of plant and for simplicity of selection, job frequency, may be colour coded to show weekly, two-weekly, monthly, jobs etc.

Note! There are various automatic selecting units for this purpose if economics prove the cost worthwhile.

Besides those already mentioned, I have three other main sources of information:-

1) Each item of plant has an Inventory Card (Fig.7) which itemises all basic details of that plant, e.g. for a conveyor I have listed motor details, size, speed, reference numbers; number, type and size of rollers; belt sizes, rubber specification and so on. The more detailed this is, the quicker you can obtain information.

2) A two page format to be filled in by the moulding plant operator (Fig.8); this gives information on overall production, production rates, downtimes and reasons for them, etc.

3) A sheet filled in by the sand plant operator detailing the utilisation of each main item in the sand plant i.e. the two sand mullers, double shaft mixer and sand aerator, utilisation being stated in working hours per day. We also logs when blades are replaced, reset or repaired.

Note! To avoid confusion each item of plant is given a Location Number, a plant number and an item number.
e.g. The sand aerator may require maintenance on its

OBJECTIVE 1 (contd.)

main drive, therefore on the weekly job sheet a location number (4) will be stated referring to the prepared sand group and also a plant number (71) referring to the aerator itself and finally its motor item number (7).

This may seem in itself confusing at first, but if Locations are kept below twenty, it becomes easier to locate plant, the item numbers are rarely important as few pieces of equipment have more than eight motors for example. Therefore if a list of plant numbers is always in the technician's possession he can locate any small item, on any piece of equipment wherever it might be on the plant.

At this point I should mention that it is wise to organise even simple things such as cleaning and in fact one can then add for example Planned Cleaning to your scheme.

A net has now been cast over your plant through which few faults should pass, however we as engineers must be realists and also psychologists, because the job is now organised and simple, the man on whom we rely may tend to grow lazy. We must therefore instil into them the importance of their job to us, to the company and to their fellow production workers.

.....

Part 2 - Staff

Foundry Engineer

Assistant Engineers - Mech[1] & Elec[1]

Clerk/ Secretary

6 Mech[1] Fitter Technicians

4 Elec[1] Fitter Technicians

2 Moulding Plant Operators

2 Sand Plant Operators

1 Oiler & Greaser

2 Cleaners

OBJECTIVE 1 (contd.)

My two assistants work alternatively 6 a.m. - 2 p.m. and 2 p.m. - 10 p.m. so that one of them is always on a production shift. Their main duties are to prevent breakdowns, get the plant running as swiftly as possible when it does stop, to control the speed of operation and generally to assist me in the efficient running of the department.

The Mechanical and Electrical Technicians work a five-day week, three shift rota:- 9 p.m. - 7 a.m., 7 a.m. - 1 p.m. and 1 p.m. - 9 p.m. These times were chosen to suit both themselves and in order to prevent shift changeover at start up or shut down periods.

The Moulding Plant Operators work alternating shifts on a weekly basis simply covering productive operation.
Note! All of the above are employed on a monthly staff basis.

The Sand Plant Operators work alternating shifts, also only on production and, in addition to operating the plant, they have various inspection and cleaning jobs.

The two Cleaners are employed on a similar basis.

The Oiler and Greaser works on permanent nights and his duties also cover various cleaning jobs.
Note! These members of my staff are normal weekly paid employees.

To cover maintenance and running as fully as possible we run a shift system which overlaps production starting and finishing, thus allowing some latitude to the maintenance staff, i.e. unless there is a breakdown they are quite free to change shifts early or late to suit their own convenience.

As most of you will appreciate the period allowed for maintenance, i.e. 6½ hours per night, would in most industries

OBJECTIVE 1 (contd.)

be quite adequate, however in the heavier, dirtier industries, such as those dealing with iron, steel, coal, etc. special attention is required. In this kind of environment equipment is working under a severe disadvantage and it soon becomes apparent that all weekends also are needed.

The seriousness of this will depend very largely upon the organisation of labour and the type of labour. On a complex automatic plant such as this with a comparatively small number of staff available at any time, some consideration must be given to breakdowns and large planned jobs, i.e. will sufficient labour be available. The answer to this can only be found within your own circumstances, but it is necessary to consider pool labour, production labour, overtime or maybe contract labour.

With regard to staff the first consideration must be:- **Selection.** Selection is not an easy task and therefore we must give great importance to it. It is of assistance to set down on paper what you require, detailing a job specification, qualifications desired, etc. Before an interview it is wise to have planned your questions in order to obtain as much information as possible and to have detailed all that you wish him to know. Before he leaves the interview be sure that he knows just what you require of him and under what terms he will be employed.

Once you have made a selection your priority now is to orientate him, where necessary, to suit your system. Try to give him a little freedom for his first two weeks to become accustomed to the plant, the general layout, operation, existing staff etc. Once he settles into the basic routine, he must then be:- **Trained** in our case to operate the plant, to understand the complex sequences, hydraulic and pneumatic circuitry and the items of non-standard nature.

OBJECTIVE 1 (contd.)

Training is also a difficult task, especially when working with limited staff who are almost immediately on employment needed to carry out full duties. As staff join my team I endeavour to give them one or two weeks on day turn and then I place them on the shift rota, but I rotate them in the opposite direction to the other staff so that they get to know all the people in the team. This also gives them every opportunity of gaining knowledge from each individual, as you appreciate each man has his forte and usually likes to talk about it.

2) I try to share out all the most challenging or technical jobs so that the new starter gets the same chance to learn, being able to work with an experienced man he can see jobs stripped down, testing, commissioning or fault finding.

3) I try to spend as much time with him personally as possible, showing, explaining, asking questions and trying to get him to ask questions.

4) I make available <u>all</u> technical information in my office and draw particular attention to certain sections of it. This information is normally only for use in my office, but on request I allow drawings, books, etc. to be taken home for short periods when it is convenient.

5) Whenever I have time I write out instruction sheets and copy extracts from manuals, which are then issued to each man. For example, I have redrawn out the most complex parts of the hydraulic circuitry, coloured it and added notes to it, in order to assist the men to learn and understand more quickly.

6) Both of my assistants are also instructed to follow a similar pattern whenever they can spare the time. Their main opportunity to train the new man is to enlighten him

OBJECTIVE 1(contd.)

on the complex sequencing of the plant and in the speed control adjustments necessary to keep it running smoothly.

7) The man is steadily initiated into plant operation by assisting in start up, shut down, changing of patterns and by relieving the full time operator.

8) My staff are required to carry out any job which comes along whether it be fitting, welding, pipework, sheetmetal work or anything else, therefore, wherever his particular experience is lacking we endeavour to train him. This sometimes requires a short training session away from the plant, but it is economical to supply this facility.

Once a man is trained he is a costly asset to our staff and it is our responsibility to use him as efficiently as possible, to control him and last but not least to satisfy his material needs, paying him a fair day's wage, looking after his welfare and also to satisfy his psychological needs by showing our appreciation, trusting him and allowing him to use his own initiative.

.....

Part 3 - Spare Parts

With regard to spare parts the first priority is that " the correct spare part must be available at the correct time", however I must say that each situation is different and only the individual engineer can sort out the spare part requirement to suit his own circumstances within his companies policy.

As a rough guide for this type of equipment an approximate value of 10% of the initial capital investment should be set on one side for this purpose.

OBJECTIVE 1 (contd.)

The task of deciding on which and how many spare parts are required is a large and complex one and should be tackled by systematically scrutinising the whole plant, item by item, deciding on the spares required for the individual items and then when the whole work is complete, deciding on how many parts are necessary. In this final decision it is necessary to consider:-

1) Will the plant function without this item?
2) If so, for how long?
3) What are the suppliers' recommendations?
4) Will a new spare be totally interchangable?
5) Can I standardise?
6) Can any existing part be borrowed in emergency?
7) In the U.K., would it be wise to purchase metric equipment?
8) Do I really need this, what will be the consequences if it is not available?
9) Do I require a spare unit or just spare parts for the inside?
10) What will be the cost of one or if purchased in bulk?
11) What quantity do I require dependent upon the delivery?
12) Would a totally new design be better than maintaining this?

Once all these and any other relevant points have been considered, your list can then be completed, quotations obtained and suppliers selected. When the orders are placed you must then ensure that sufficient and organised space is available for stocking them on receipt. There now remain four considerations:-

a) They must be readily available at all times.
b) They must be easily located.
c) They must be in good, ready for use, condition.
d) They must be easily controllable for stock/cost purposes.

.....

OBJECTIVE 1(contd.)

Part 4 - Readily available information, drawings, and correct equipment to tackle any job.

I have already stated that all information is at all times available in my office. But it must be appreciated that our mechanical or electrical staff are neither filing clerks nor magicians. For this reason, it is imperative that information is filed as simply as possible, using written indications to make the finding a rapid process.

In these circumstances the importance of issuing as much personal information as possible is very great.

To ease the problem of supplying information I am able to utilise my two assistants as they cover both production shifts. They both are in a position to know the files considerably better than the fitting staff and also of course they will normally know the job to be tackled from past experience or from their reading and study of plant manuals.

They are also able to prepare information for jobs which are due to be carried out on night turn. Whether it is a breakdown or a planned task does not matter, they should be able to supply all relevant information, drawing and equipment.

As a final comment on this subject, it should be borne in mind that any drawing going out of file on to a job will probably return either in a very dirty state or not at all. This is much more evident in the heavier, dirtier industries, therefore new drawings should be obtained straight away to bring the files to a 100% information facility. On a large complex plant it may be advisable to have a book in which details of all borrowed information can be entered.

OBJECTIVE 1 (contd.)

Planning of jobs

This is a well proven asset to any plant if all information drawings and equipment are available in advance this will considerably speed up the job and also prevent mistakes being made.

Besides this, on large jobs and programmes for holiday shut-down work, it is a relatively easy, but a very profitable exercise to plan out the jobs in detail. Step 1 is to decide on the jobs to be done; Step 2 list what labour is available; Step 3 what does each job involve, i.e. a breakdown of trades required, stages of dismantling, repairing, overhauling, rebuilding, recommissioning, etc., what spares are required and so on.

It is now easy to list separate sections of each job and to draw up a "Bar Chart" or even carry out a "Critical Path Analysis".

In my case this year I drew up two large "Bar Charts," one for my office and one for the workshop showing what each job involved, when it should start and when it should finish and also how critical it would be if the job should overrun its allowed time. From this as jobs progressed, labour could be increased or decreased as required.

I also gave each man a list of his personal jobs for each day as extracted from the chart, this he received two weeks before the holiday shut down so that he was able to prepare himself by checking on drawings, tools and spares etc.

When planning work like this it is wise to allow a little surplus labour to cover any job which may prove unexpectedly difficult.

OBJECTIVE 1 (contd.)

The subject of tools and equipment is usually an easy one as they exist from previous plants and existing labour, but in our case this was a new plant, a continental plant and a new labour force. The way in which I tackled the problem was as follows:-

1) Each man should supply the normally expected "English" hand tools.
2) Each mechanical technician should be supplied with all the necessary metric hand tools, i.e. socket wrenches, open ended spanners, ring spanners, torch, tool box, cupboard, metric rule and also various expendible hand tools such as files, hammers, punches, screwdrivers and chisels.
3) Each electrical technician should be supplied with spanners up to 15 mm., socket wrenches up to 10 mm., cupboard, tool bag, Avo multi minor Mk4 meter, and a special Telemechanique tool kit.
4) Tools to be shared by the whole department. These included large metric spanners, all normal large adjustable spanners, wrenches, pipe wrenches, etc., socket spanners, taps and dies, sledgehammer, 100' English/Metric steel tape, hide and copper mallets, punches, circlip pliers, shears, metric measuring equipment, electrical testing equipment, soldering irons, test lamps and kits, all English and metric twist drills for drilling and tapping sizes up to 56 mm., stud extractors, hydraulic pulley/bearing extractors, pinch bars, clamps and so on.
5) The general workshop is laid out with the usual benches, vices, grinding machine, pillar drill, centre lathe, mechanical saw and also electrical and pneumatic hand tools such as drills, grinders, hand lamps etc., hydraulic tube bender, ladders, steps, and so on.
6) Oxyacetylene welding equipment and an electric arc welding set (60a.).

OBJECTIVE 1 (contd.)

7) Various hydraulic jacks, skates, chainblocks, Tirfor, pul-lift, monkey carriage, chains, wire ropes, slings and shackles.

Note! All of these have to be kept in first class condition to comply with statutory tests.

8) Special equipment. Pumps to suit oil, water or sludge. Safety belts, ropes and rope ladder, and also various tools to suit specific manufacturers equipment.

9) Firefighting equipment. For this purpose we have 11 off B.C.F. 7 lb. extinguishers which are suitable for both normal or electrical fires, 4 off $C.O_2$ 7 lb. extinguishers and one $C.O_2$ 150 lb. mobile extinguisher.

This equipment has up to now been quite adequate in most cases and as we have another engineering department close by it need not be increased. Our equipment has also been added to in the form of special tools, jigs, etc. made by ourselves.

Note! For big jobs, cranes or heavy lifting tackle can be hired at a few hours notice and this proves very economical. The use of stacker trucks can be an asset within the limits of safety.

In conclusion to this section of my paper I would like to repeat that the successful running of your plant and department depends upon your organising of it; its cost, its speed, its cleanliness, its overall efficiency, the way in which the work is carried out is your responsibility, therefore think, prepare and act now to save later.

OBJECTIVE 2 - WHAT, WHEN AND HOW TO MAINTAIN OR REPAIR

An item must be maintained in order to keep it at or as near as possible to 100% efficiency.

An item must be repaired whenever that 100% efficiency is being or likely to be impaired.

Replacement comes between the two and the engineer must decide when to repair or replace.

To decide, these questions must be asked:-

1) Can it be maintained?
2) When and how can it be maintained?
3) What will it cost to maintain?
4) Can it be repaired?
5) How long will it take to repair?
6) What will it cost to repair?
7) How will it affect production?

Even when an item is regularly maintained, sooner or later it will become less than 100% efficient, then at this point further questions should be asked:-

8) When repaired how long is it likely to stay efficient?
9) Will it repair a second time?
10) Would it be more economical to replace the item?

In the asking of all these questions it must be realised that each industry, each machine, has its own characteristics. Each engineer will know his staff, equipment and spares, therefore the examples I give in my paper need not be the exact answer in all cases.

OBJECTIVE 2 (contd.)

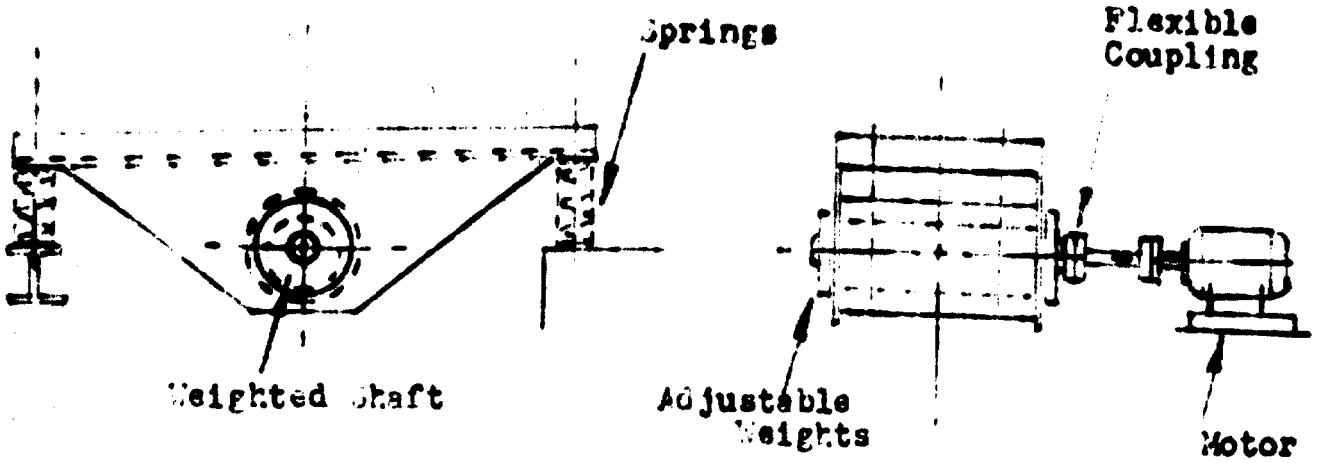
I intend to cover this section in the following manner:- to describe each of the following sections and then to itemise the inspections, lubrication and maintenance required by that plant.

1. Vibrating chutes or sieves
2. Pneumatics
3. Pneumatic conveying system
4. Hydraulics and hydraulic equipment
5. Electrics Conventional, including switches, contactors, relays, instruments.
6. Electrics Solid State
7. Level controls
8. Box transfer equipment
9. Moulding machines
10. Electric motors
11. Speed reducers (gearboxes), clutches and couplings
12. Sand Plant (supplement)

1. Vibrating chutes or sieves

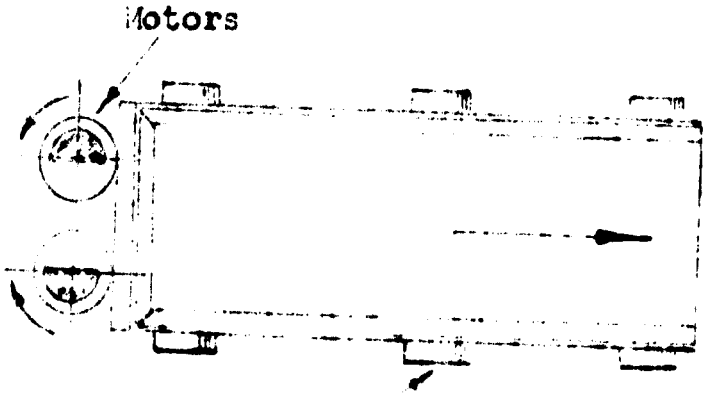
These are used to sieve, separate or transport sand and castings. They may be of two basic types:-

1) When the chute itself is supported on springs or rubber pads, whilst a large out of balance weight is rotated inside the body of the chute to obtain the necessary vibration.



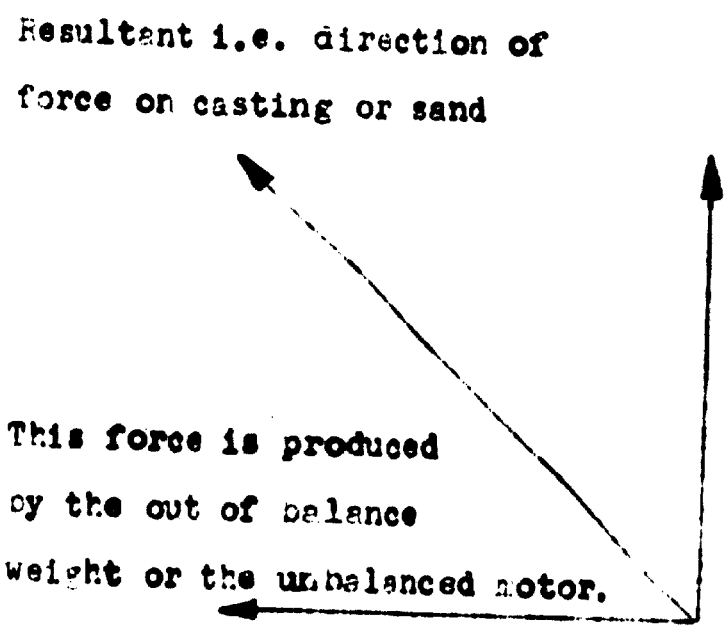
OBJECTIVE 2 (contd.)

2) When the chute is again supported on springs or rubber pads, whilst the vibration is obtained by a pair (or more) of dynamically unbalanced electric motors



Note: the angle of the rubber pads and inclination of the chute determine the amplitude of vibration.

In both cases during design the resultant angle of throw has been arrived at and the equipment will show by markings how to increase or decrease vibration whilst still attaining a flow of sand or material.



The following are the necessary inspections to be carried out on this type of equipment.

Daily Inspection

Visual a) Is there any apparent malfunction! i.e. poor vibration; if in doubt this may be checked by placing a piece of paper on the side of the

OBJECTIVE 2 (contd.)

vibrator and with the aid of a pencil drawing a vibration chart, this should be constant and the amplitude of vibration is known from experience or calculation.

b) Condition of springs, rubber pads, etc. i.e. splits wear, cracks, weakness.

c) Sand build up.

d) Loose or missing bolts, wear on the chute face.

e) Motor fixing and coupling condition.

Physical (and audible)

a) Temperature of motor.

b) Temperature of bearing housing, noise in bearings.

c) Motor current rating.

d) Sand building up should be removed (by the cleaner on instruction).

2-Weekly Inspection (on maintenance shift)

a) Check couplings.

b) Check out of balance weights for fixing security.

c) Check on condition of springs and motor pads.

d) Check on wear.

e) Check with spanner nuts and bolts, also steel structure and foundations.

Lubrication

a) Main bearings are given a small amount of grease once or twice per week. Grease as per suppliers recommendations.

b) Electric motors a very small amount 6-monthly and to be repacked 1 or 2-yearly dependent upon conditions, i.e. where they are running in very dirty or hot conditions, yearly.

Maintenance

a) Tighten all nuts and bolts and replace any badly worn fixings.

b) Thoroughly check all welded joints and re-weld if required.

OBJECTIVE 2 (contd.)

c) Repacking of bearings, also oil seals, bearing, key and keyway checks.

d) Maintain electric motors (see separate section).

e) Replace bolts in flexible coupling (this of course depends upon the type of coupling).

f) Replace springs when they begin to lose their resilience or if they crack. The life of these springs will become known by experience and should be changed before becoming inefficient or broken. They should last about two years.

g) Replace rubber pads when they begin to lose their resilience, crack or start to harden. These also should last about two years.

h) Replace sections or the whole of the wearing plates on the chutes as necessary. These are usually both bolted and welded and take considerable time to remove, especially when the bolt or socket head cap screws are extensively worn.

These plates should have a life of well over one year, even in the most hard wearing places.

Because of the time consuming nature of this job it may be worthwhile considering your first replacements long before the plates require it and laying the new ones over the partly worn plates. This gives a good piece of equipment even if they wear right through, due to say poor delivery of new plates, which can easily occur on special steels.

General Notes

This type of equipment has to withstand many arduous conditions which cause particular weak spots and in order to save unnecessary downtime we must be aware of them. The first problem is the severe vibration, this is normally at a fixed frequency and amplitude, but on starting and even more so on stopping, this

OBJECTIVE 2 (contd.)

becomes out of phase with the motor driven weights. Due to this we must pay continual attention to bearings, security of fixing, spring and rubber pad condition. Secondly, vibration combined with the heat involved in transporting hot sand and castings, causes stress cracking in both welded joints and bolted fixings.

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2. Pneumatics

The most important factors when dealing with air are to be sure that you have enough when you need it, i.e. your requirement may vary considerably, and that it is dry when received.

1) If your supply is not quite adequate during short fluctuating peak periods then an extra air receiver or receiver/ring main should be added in the appropriate place to deal with this variation.

2) If your supply is wet it should first be tackled at the source, i.e. the compressor, aftercooler, separator, etc. Here air entering the compressor can be controlled or the temperature of the cooling water improved etc. If no improvement can be made in this area, then it should be checked that your main line filter and air receivers are drained regularly and efficiently (this may be manual or automatic). There are two remaining ways of removing further water:-

   a) in-line separators and correctly placed drain traps,
   b) air filters placed as close as possible to where the air is required (it is usually advantageous to combine an air lubricator with this type of filter).

OBJECTIVE 2 (contd.)

There are also three simple facts which are so often overlooked which can increase your efficiency and reduce your problems:-

a) Water is continually separating from the air as it cools therefore be careful as to the routing of your air lines.

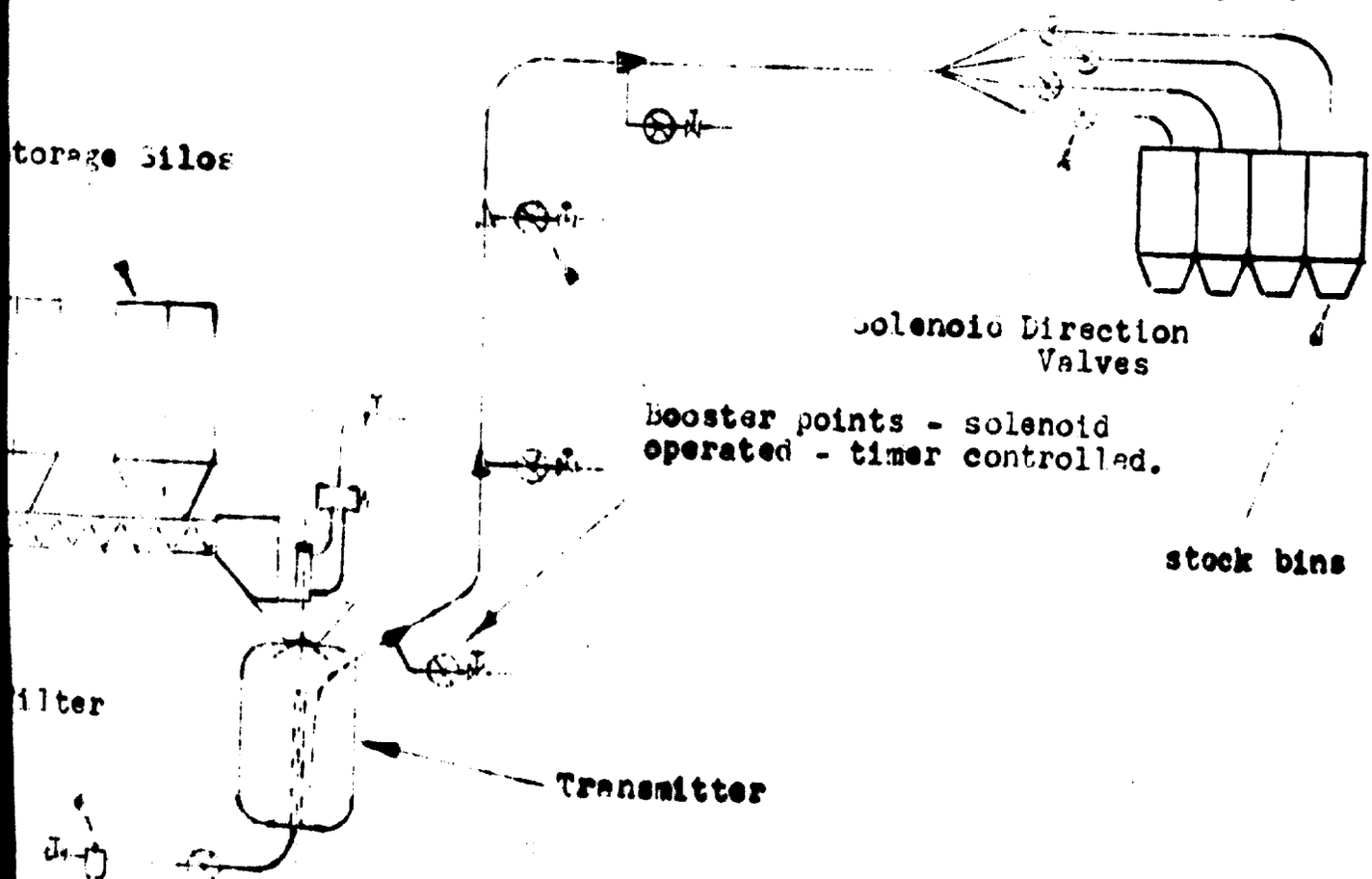
b) Pipe lines feeding items of plant should always come off the top of the main line.

c) Incorrect choice of valves or pipe sizes can easily create a situation liable to induce freezing.

.....

3. Pneumatic Conveying System

The pneumatic conveying of powders can be a most efficient mode of transport as long as forethought and planning are given at the design stage and during commissioning. Once working little trouble should be encountered and little maintenance required, **except** when there is an ingress of damp air or liquid.



OBJECTIVE 2 (contd.)

Our particular system has a transmitter which receives approximately 6 cu.ft. (0.17m^3) of powder from a pre-selected silo by means of an Archimedian screw conveyor, this is stopped when a level controller is permanently touched. This signal also actuates the mechanism to seal the transmitting chamber. Air is then allowed to enter through a non-return valve, into the top of the chamber and the pressure begins to build up. After about 3kg/cm^2 the powder begins to travel from the bottom up the feed pipe, at this point a booster 1 metre along the pipe is automatically switched on and after given periods a further three boosters spaced at approximately 13 metre intervals are also used. The principle is that once in suspension the powder is easily blown and kept in suspension by the boosters.

Each transmission takes about 3 minutes, but we allow 4½ minutes to fully clear both chamber and pipework, this we found necessary by experiencing pipe blockages.

Inspection Twice Daily (for all pneumatics) and also Nightly

a) Drain all air lines where manual and check operation where automatic.

b) Check all filtering equipment, valves, pipe joints, etc.

c) Check operation of transmitter.

d) Check transmitter seal i.e. air cylinder and valve. Check for operation, pressure loss, damage or wear. Note! the valve should seal in the automatic cycle as we check the piston rod stroke by means of a reed switch.

e) Check for any air or powder leakage.

f) Check bearings on Archimedian screws.

Inspection 2-weekly

a) Check all valves, cylinders and solenoids by individual operation and selecting a sample valve to strip down for internal inspection.

OBJECTIVE 2 (contd.)

b) Check electrical loading on the feed screw motors under both "load" and "no-load" conditions.

Lubrication

We no longer lubricate the air as this was found to cause blockages, but whenever valves are stripped down a small amount of graphite or a thin film of oil is wiped on the moving parts.

Maintenance

a) Over a 3-month period all valves are stripped down and checked.

b) Pre-selection valves which have rubber inserts require internal inspection and sometimes repair 6-monthly.

c) Replace filters as soon as they become inefficient.

d) Strip screw conveyor 6-monthly to inspect for wear, corrosion or damage, re-seal and commission.

General Points

When blockages do occur, do not bang pipes with hammers, on occasions banging may be beneficial, but it is wise to use a mallet, as deformation of pipework creates incorrect air flow and tends to cause obstruction points.

Build as many inspection points into the system as is feasible, this will cut down on fault finding time.

As a guide to the suitability of a pneumatic conveying system in given circumstances various organised bodies have studied this subject and in general the system should not be required to transmit much over 350' (110m) nor to elevate the material much over 60' (18m).

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OBJECTIVE 2 (contd.)

4. Hydraulics

Because this is a vast subject I will only discuss the main items of equipment on our plant.

Low Pressure Pumps

These are Constantin Houche bent axis, axial piston pumps and require little maintenance. It is my practice to send them away to the manufacturers as soon as they become inefficient to be overhauled, this is due to the rather specialised nature of pumps and because foundry conditions are not conducive to this work. They normally run at approximately 97% when new.

Pump efficiency can be checked accurately by using the formulae supplied by the manufacturers but it should be realised that this must be checked on installation and again at regular intervals to obtain a relative and true figure.

Besides the correct accurate check there are three other simple ways of appraising these pumps:-

1) Check the time for each pump to give a required output pressure from start up (Note! the accumulators must be emptied each time).
2) Check the 'on' and 'off load' current of the electric motors.
3) Check the pump leakage in a given time.

Again note that all these figures are relative and must be checked regularly right from installation.

Inspection Daily

a) Check for leaks.
b) Signs of cavitation or air intake, anywhere, must be checked for.
c) Check motor and coupling.
d) Check pump pressures on and off system.
e) Check pump for undue heat, noise or vibration.

OBJECTIVE 2 (contd.)

High Pressure Pump - a radial piston pump by Rual

All comments are as for other pumps but in addition we check the piston, valve and cam follower for wear, damage, etc.

Oil Reservoir - (3000 litre capacity)

This tank receives all the return oil via a filter which has six sets of stainless steel mesh (75 micron) and a magnetic core, and is set into the tank top. It then supplies oil at a minimum of 150 mm. positive head to the pumps (this is usually 1000 mm. head) thus reducing the possibility of cavitation.

Now that I am using a water in oil emulsion the tank is always kept full by means of a header/filler tank. The reason for this is that where large volumes of air become trapped, evaporation tends to occur under the prevailing conditions of temperature and even though the fluid contains an anti-oxidation addition this vapourises off after continual re-circulation. In order to prevent rust therefore the oil level is kept high and its surface area small. This level is checked automatically at three separate levels by means of an electromagnetic float switch, in fact when the third level is reached, the whole plant automatically shuts down. We also check on the inspections by visual sight glasses, topping up as soon as is required.

Inspection Daily

a) Check oil level.

b) Check oil temperature (normally between 26°c - 56°c).

c) Check immersion heaters in winter (these prevent the oil temperature in the tank falling below 26°c.

d) Check for oil leaks.

e) Check for ingress of air.

OBJECTIVE 2 (contd.)

Maintenance

a) Remove and clean filter monthly.

b) Check temperature gauge against laboratory equipment.

c) Check operation of water cooler (only used over 30°c).

d) Remove reservoir top, check for rust, presence of foreign matter, separation of mineral oil, then re-seal top, 3-monthly.

e) Change all oil in system after approximately 5000 hours or before if required. The oil is tested weekly for three weeks after oil change, then monthly for:-

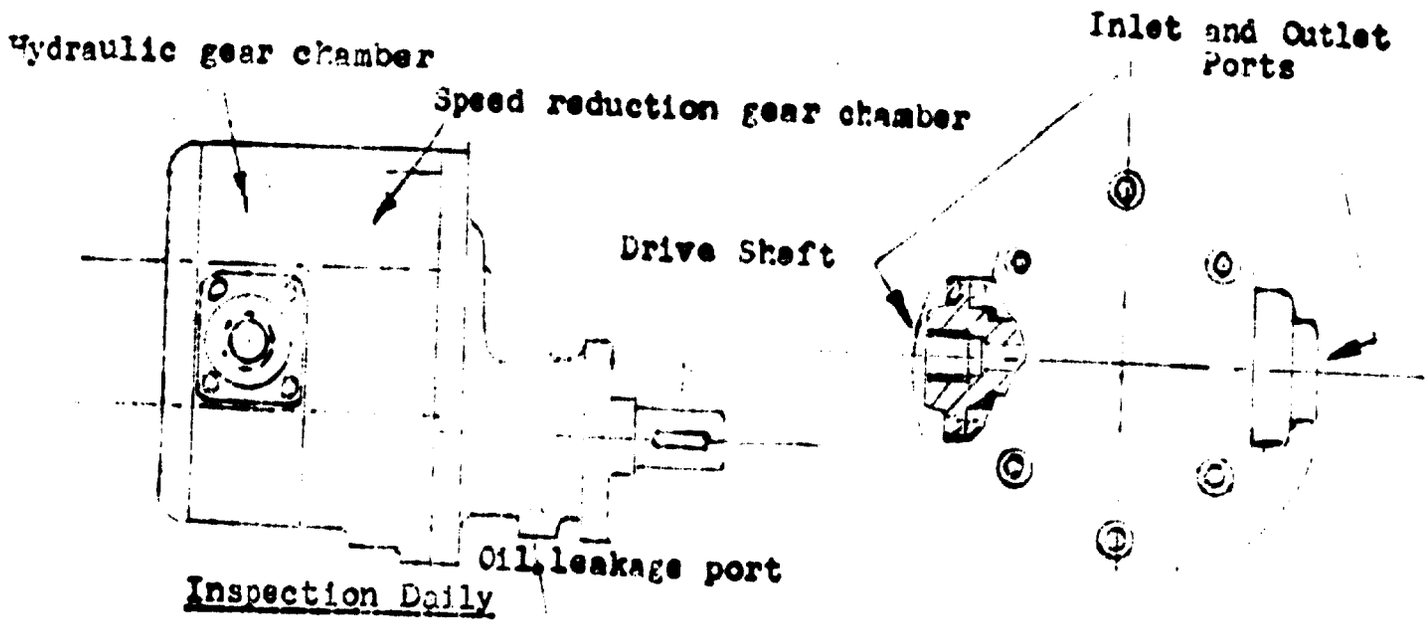
water content
viscosity
percentage of suspended matter
dispersion i.e. are the water particles still below 2 microns.

Hydraulic Motors

These convert oil flow into rotary motion by means of a gear chamber. In our case this rotary motion is then transferred through a flexible coupling and double chain sprocket into lateral movement i.e. we transfer 4 moulding boxes weighing approximately 1 ton, a distance of 2½ metres, by means of a carrier. This moves the boxes along on rollers, disengages and then returns to ground position.

This equipment undergoes a very arduous duty, as does the flexible coupling and both require constant inspection. The motor is protected as far as possible by control valves, which must work perfectly if the motor is to be guarded against sudden stopping, starting or reversal of direction.

OBJECTIVE 2 (contd.)



Inspection Daily

a) Leakage of oil, control valve settings and operation.

b) Noise, excess temperature, vibration or any incorrect function.

c) Check securing bolts.

d) Check coupling (this is now possible as we have added inspection panels.)

e) Wear, misalignment or stretch on the chain and double sprocket.

Lubrication

Sprocket bearings 2-weekly (these are journal bearings).

Maintenance

a) Change seals when necessary (slight leakage will show this).

b) Strip down 3-monthly for internal inspection, fit new joint seals.

Note! On this unit the oil leakage pipe must be at the bottom when installed and must be large enough. This is because, should any protecting valves fail, the leakage can be excessive and if the pressure is not relieved the seals will be damaged.

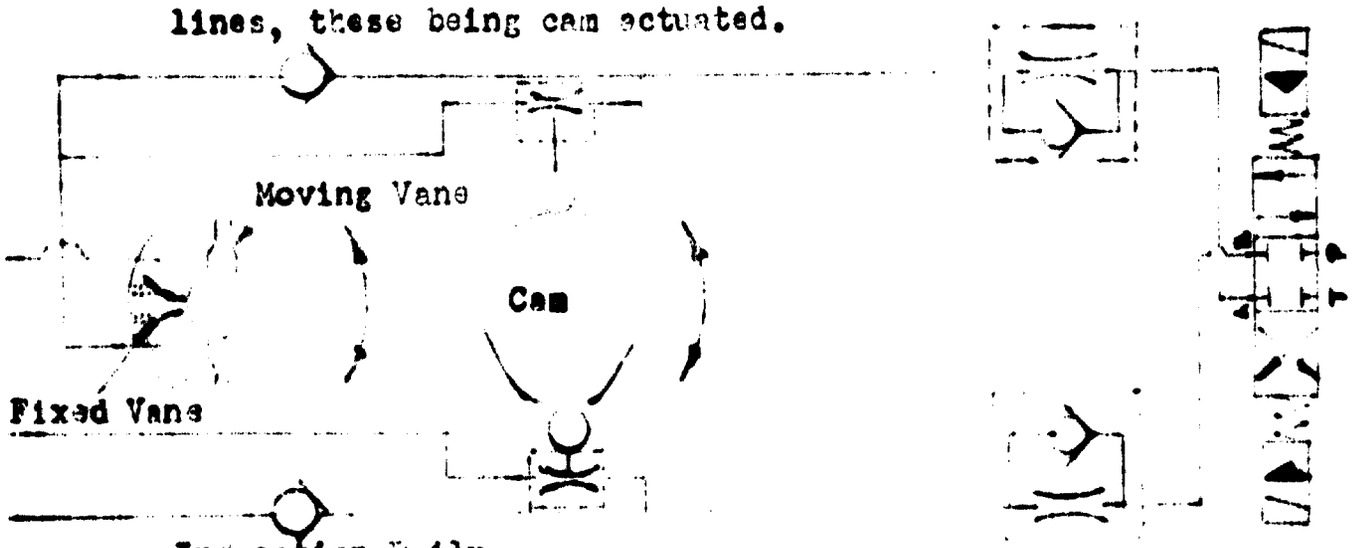
Rotary Actuator

This equipment converts oil flow into a 180° rotary movement for turning our moulded boxes over, these weighing

OBJECTIVE 2 (contd.)

approximately 300 kg. It consists of a cylindrical chamber which contains a fixed vane attached to the outer shell and which seals against both ends and the centre rotor shaft. This rotor shaft also has a vane attached and it seals against both ends and the outer shell, so that when oil enters between the fixed vane and the rotor vane and oil is allowed to leave by a port at the other side of the fixed vane, then rotation is obtained.

This operation is controlled mainly by two "shut off" valves on the return sides and a bye-pass for the pressure lines, these being cam actuated.



Inspection Daily

a) Check for oil leaks, valve settings, cam wear and valve operation.

b) Check for excess temperature, noise, vibration or any incorrect operation.

c) Check securing bolts (this is very important due to high torques involved.)

d) Check alignment.

Lubrication

Main bearings a small amount daily (these are phosphor bronze bushes.)

OBJECTIVE 2 (contd.)

Maintenance

a) Adjust flexible coupling monthly.

b) Strip and inspect main bearings 3-monthly.

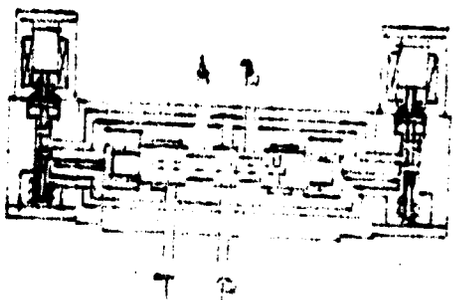
c) Actuator vane seals need changing 6-monthly, also shaft oil seals.

d) Actuator rotor bushes need changing yearly.

Control Valves

We have about 85 solenoid operated spool valves of various types and sizes, but mainly as the one shown below.

Symbol



Valve Section

By courtesy of G. L. Rexroth

Also in the circuits there are various safety relief valves, pilot operated non-return valves, 45 normal non-return valves, 64 throttle/non-return valves, 18 throttle valves (regulators) and 28 cam operated shut off valves.

When controlling a system such as this it should be realised that perhaps half of these valves will require regular adjustment especially in winter when the oil temperature rises very quickly during the first hour of production (26°c up to 56°c). It is therefore of immense importance that your staff know the system well and particularly which parts of the automatic sequence must be strictly adhered to, i.e. in some instances a slow action of say a hydraulic cylinder can stop our plant, this is because timers are used in the automatic sequencing.

OBJECTIVE 2 (contd.)

In our case this is done mainly by the permanent operators, myself, or either of my assistants, but fitter technicians should be trained to do it, so that any malfunction noted on inspection can be immediately rectified.

Inspection Daily

a) Check for leaks, worn cams and rollers.

b) Check for incorrect operation of valves (weak or broken springs, inadequate throttling, incorrect adjustment, etc.)

Maintenance

a) Internal inspection of spool valves, this is only done 6-monthly or if a fault occurs. The reason for this is that a foundry is not a perfect environment for hydraulic equipment and more damage can be caused by ingress of dirt, etc. than by leaving a valve to show a fault.

However, it is wise to carry a spare valve of each type for immediate exchange when faults do occur, the other being repaired in the relative cleanliness of the workshop.

b) One exception is made to the above and that is to check the centreing springs 3-monthly.

c) The solenoid blocks are checked electrically and mechanically approximately 3-monthly.

d) The throttle/non-return valves require a new spring and "O" rings every 6 months in the case of those being used and adjusted most. (These control about 6,000 operations per day). Spares are kept for immediate interchanging.

e) "O" rings in any valve are changed when leaks occur and can not be rectified by tightening of screws, etc.

Note! Some valves are affected by the oil temperature and require replacing regularly. In these cases it is wise

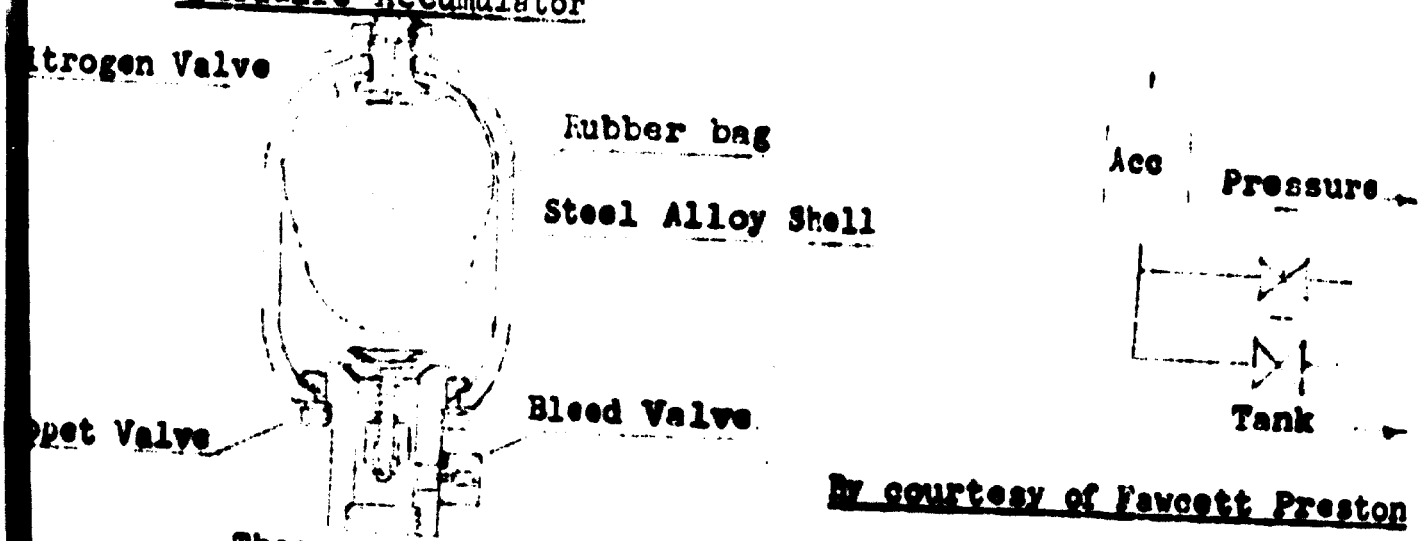
OBJECTIVE 2 (contd.)

to check whether or not they are re-usable on cooling. This has been the case with us on the pump relief valves, these operate up to 15,000 times per day and after about one month fail to control the pump "off system" valve. We simply replace them, allow the used one to cool, check it for spring compression, wear and "O" ring wear and then return it to stores for further use.

These valves can be exchanged and set in 10 minutes so it is my policy to exchange them only when inspection shows them to be out of order. These same valves and their counterparts which bring the pumps onto system again (electrical switches pre-set to operate a solenoid operated spool in the valve) require a monthly check and adjustment as they tend to move under vibration and temperature.

Note! <u>The most important factor in hydraulics is cleanliness.</u>

<u>Hydraulic Accumulator</u>



<u>By courtesy of Fawcett Preston</u>

These as you may know consist of an alloy steel cylinder containing a strong rubber bag; this bag is pressurised by nitrogen or similar gas to a pressure just below the maximum line pressure (a formulae is used to determine this)

OBJECTIVE 2 (contd.)

and the cavity between the cylinder and bag is actually part of the hydraulic system containing oil. On the bottom of the cylinder is a poppet valve. When the pressure in the system is high then the bag is compressed (pressure of oil equalling pressure of gas). Now when the system requires pressure which is momentarily greater than the pumps can supply, the stored energy is released as the bag expands. In theory this operation may be visualised as the operation of a fly wheel in an engine.

The accumulator is therefore able to take shock loads from the system, supply power at instants of low pressure, and overcome to some extent, valve leakage.

Hydraulic Cylinders

We have 42 cylinders ranging from 50 mm. bore x 150 mm. stroke up to 250 mm. x 475 mm. stroke and 33 mm bore x 1400 mm. stroke. Some of them are cushioned but most rely on cam operated "shut off" valves for smooth, safe, operation.

Inspection Daily

a) Check for oil leaks at connections and seals.

b) Check condition of piston rod and scraper seal.

c) Check security of fixing.

d) Check piston rod fastening.

e) Check cams and rollers.

f) Check for correct operation.

Maintenance

Work is carried out when inspection shows it necessary, this is because the exchange of seals, etc. under a planned preventive maintenance scheme does not prove economical under this environment. By this, I mean that seals could

OBJECTIVE 2 (contd.)

be changed one day and require changing again the next, due to excess sand falling on them or being subjected to hot metal or being damaged by scrap metal.

Therefore we keep a spare cylinder of each type and size together with the appropriate seals and packings.

Fault finding on hydraulic systems can be complicated and frustrating, therefore train every man to know the system and the equipment. He should be encouraged to study the system and employ his mind in a logical manner.

The only other aid to fault finding is a series of testing points and gauges in the most appropriate parts of the circuit.

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OBJECTIVE 2 (contd.)

5) Electrics Conventional, including switches, contactors, relays, instruments.

Contactors and Relays

As with solid state switching these are best installed in dust proof cubicles.

We have approximately 100 contactors, relays and fused isolators installed in two such cubicles.

The maintenance programme that should be put into operation is:-

Daily Inspection (with plant operating)

1. Inspect switching cubicles for ingress of dust and liquids.
2. Check contactors for hot spots and noisy operation.

Weekly Inspection (with plant operating)

1. Clean out cubicles.
2. Check voltages of supply and control circuits.

Monthly Inspection (with plant operating)

Check for "volt drop" across contacts recording any with a voltage above [illegible].

Monthly Inspection (with section of plant shutdown)

1. Check tightness of terminals.
2. Clean or replace contacts that have been recorded as having a "volt drop".

Before completing this section of electrical maintenance thought must be given to the testing of items that are built into the plant as safety features and are required to work in an emergency, i.e. over-pressure or overtemperature switches, solenoid operated emergency shut off or reverse valves, important maximum or minimum level controls, etc.

OBJECTIVE 2 (contd.)

A programme of tests must be made out for these items.

Maintenance of any equipment whether conventional or solid state can be simplified and accelerated by means of correct tools and testing equipment, but also remember that we can usually go one step further and where applicable, install automatic testing or test rigs local to the equipment. One simple example of this is that in one of our cubicles we have built a simple fuse tester costing no more than £1 and yet available to test any or all of the 300 different fuses in that section.

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Transformers and Rectifiers

These items of plant require very little maintenance but inspections must be made to see that these units are kept clean and have enough free moving air to ensure cooling. Also periodic tests must be made to check the voltages and resistances.

Under normal operating conditions a 10% variation should be allowable before a re-wind is deemed necessary. If they are of the oil immersed type, check oil level taking care on filling so that no excess oil is left lying around and also that no foreign bodies are allowed to enter. On inspection check the equipment for hot spots.

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Instruments

Because of the many various types of instruments that are in use it is difficult to lay down a general programme for maintenance but there are two very good rules which must be observed.

OBJECTIVE 2 (contd.)

a) Make certain that your technicians who maintain the instruments understand fully the type of instrument, either by the technicians undergoing instruction by the manufacturer or at least reading the instruction manuals supplied with the equipment.

b) As the tools, test and calibration devices, cleaning fluids and lubricants are of a special type, it is very good practice to keep these in a special case and to use them only when maintaining the instruments. This also means that no improper tool should be used such as pliers or grips which can obscure vision or damage intricate mechanisms, screws, etc. so easily.

Inspections should be carried out regularly and tests carried out to check the accuracy and operation of each instrument. Dependant upon the conditions prevailing it will be advisable to give them a thorough check and clean at about 6-monthly intervals.

Generally it is my practice to decide on inspection whether or not an instrument is reparable. If it is decided that repairs can be made we then have to decide:-

1) Can we undertake that repair?
2) Will it be wiser to return it to the manufacturer for specialised repair?
3) Is it really economical to repair?

e.g. a) A gear fails in an electric control timer - replace and repair.

b) Failure of an ultrasonic control unit;

little is known of this unit - replace and return unit to manufacturers for recommendations.

OBJECTIVE 2 (contd.)

c) Broken indicator needle on an instrument - repair on site.

d) Bourdon tube damaged in pressure gauge - replace the whole gauge and write off the damaged gauge.

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Note!

Although we are required to maintain many other items such as lighting and heating, I do not think that time allows me to cover these except to say that good lighting and heating improves health, efficiency, safety and morale, and therefore it is of utmost importance to cover these under your planned maintenance scheme.

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6. Electrics - Solid State

Our system utilises approximately 2,500 static switching and controlling modules for automatically controlling the moulding plant sequence. All of these are contained within a cubicle measuring only 1400 mm. wide x 2600 mm. long x 2000 mm. high, including the necessary space for maintenance, testing, etc.

One of the other reasons for using solid state switching is that the maintenance required is very low. This low maintenance is apparent not only in the control modules, i.e. no moving contacts, etc., but also in the sensing devices. As the proximity switches are untouched they have a great advantage over the mechanical limit switches which easily get damaged.

Following this statement one must not be led into believing that this section of the plant can be left without any attention.

Solid state switching units are best installed in dust proof cubicles with a controlled temperature, care being taken to

OBJECTIVE 2 (contd.)

see that the temperature of the switching units does not exceed 45°c.

Besides heat and vibration the biggest enemy to solid state controls is the possibility of voltage fluctuation and this must be adequately safe-guarded in the power pack units. Normal power pack supply outputs 36v.

The maintenance programme that should be put into operation should include these switching cubicles, remote proximity detectors, remote switch and push button stations.

Daily Inspection (with plant operating)

Inspect for: 1. Mechanical damage to cables and proximity detectors.

2. Ingress of dust and liquid into switching cubicles, switch and push button stations.

Weekly Inspection (with plant operating)

1. Clean out switching cubicles, switch and push button stations.
2. Check voltages from power packs.

Monthly Inspection (with plant shut down)

Check tightness of terminals on cables between units.

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7. Level Controls

As solids are the common material that is handled in a foundry, the level controls used are of the capacitance type. This type of level control is so constructed that the maintenance required is very low.

Ours are 220 v single phase supply transformed down to 16 v, then Solid State internal operation. The actual sensing

OBJECTIVE 2 (contd.)

is the capacitance between electrode and hopper, i.e. through the sand.

A good maintenance programme would be:-

Daily Inspection

Inspect cables for mechanical damage, special care where flexible cables are used and where heat, wear, loading dampness, etc. are likely.

Monthly Inspection

Inspect for ingress of dust or liquids into level control sensing heads and for corrosion to level control probe.
Check terminals for tightness.
Finally test operation and adjust sensitivity to its optimum value.

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OBJECTIVE 2 (contd.)

3. Box Transfer Equipment

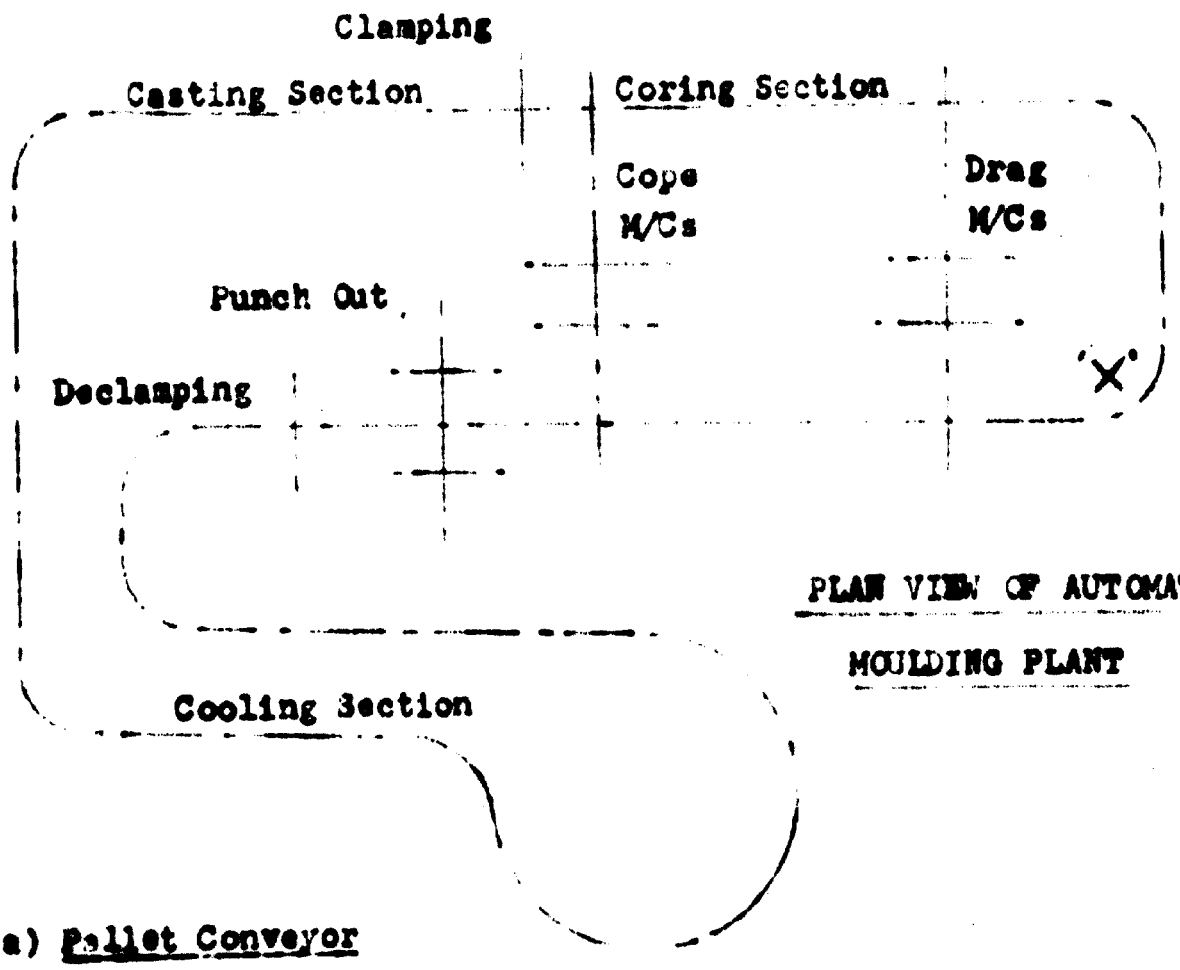
This section comprises of mechanisms designed and manufactured by Badische for:-

a) conveyance of the moulding boxes from pouring, through the cooling section, punchout device and back to the moulding machines. This is known as the pallet conveyor.

b) punch-out device

c) box lifting, separating and closing units

d) carriers to transport boxes through the machine.

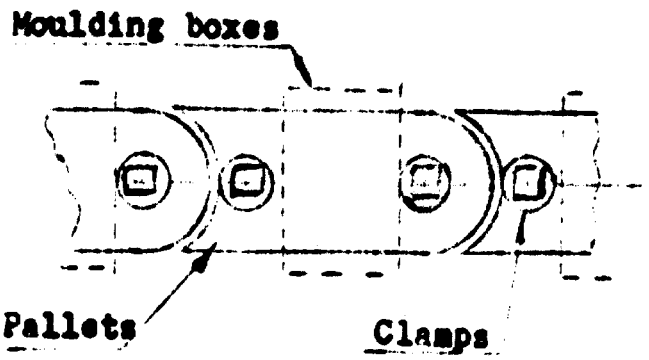


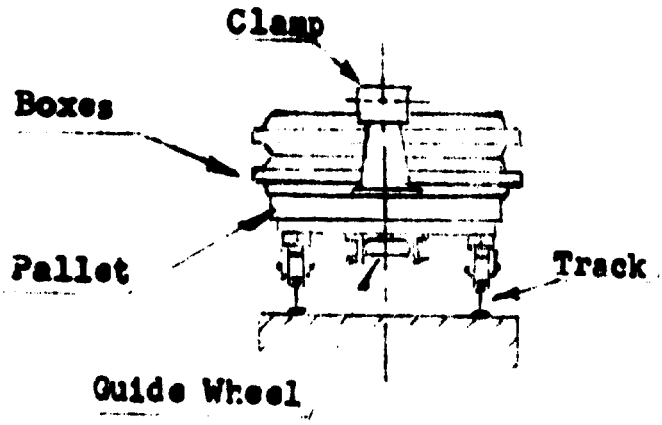
PLAN VIEW OF AUTOMATIC MOULDING PLANT

a) Pallet Conveyor

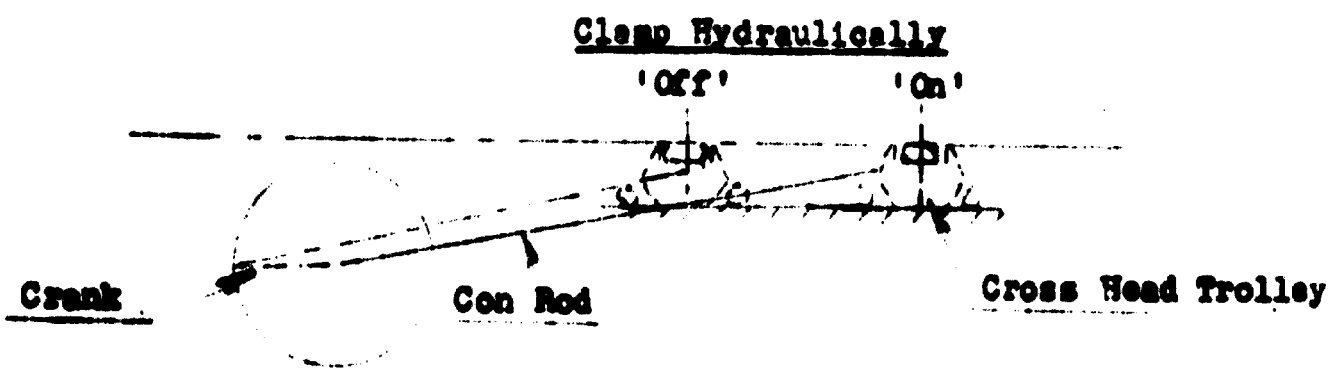
This is made up of 131 separate pallets, each connected to the next by one pivoting point and supported by two wheels which run on a rail track. The whole being guided round by a centre roller beneath the pallets which is constrained in a guideway.

OBJECTIVE 2 (contd.)

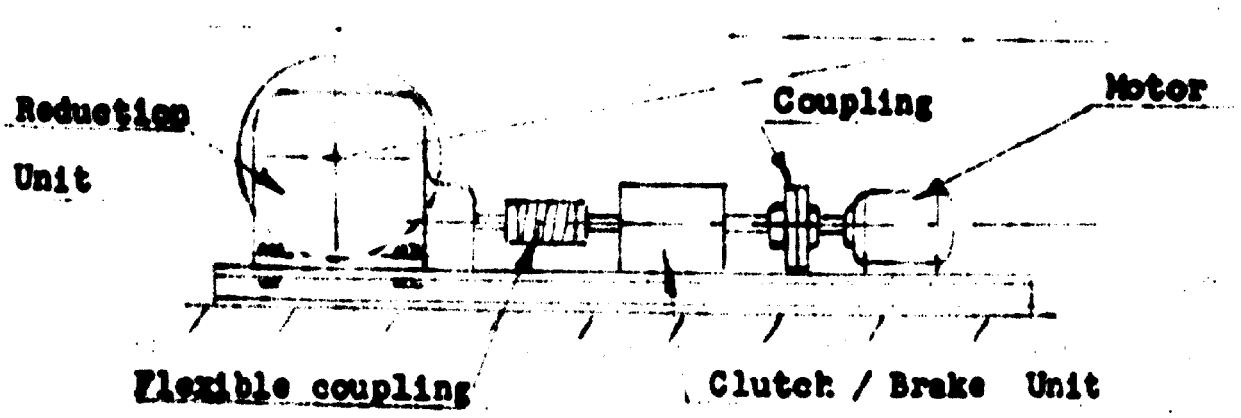




The track movement which is an indexing movement of 1210 mm. for each cycle is obtained by means of hydraulically clamping the guiding roller (this is done below ground level at the coring section) and transporting the whole unit through one index utilising a crank/con rod mechanism.



The crank disc is rotated as shown below:-



Inspection Daily

a) Check clamping pillars for damage, incorrect operation , stiffness, weak spring, bolt fixings.

b) Check wear on wheels, guide rollers, guideway.

c) Check track fixings, guideway fixings, especially fish

OBJECTIVE 2 (contd.)

plates at corners (here the greatest forces are involved).

d) Check for molten metal which may have been spilt on the pallets.

e) Check crank bearings, con rod connection to clamp, clamping operation, wear or looseness of clamping mechanism, wear in cross head slideway.

f) Check security of main reduction unit and oil level.

g) Check all proximity switches.

Lubrication

a) Pallet guide rollers are greased 2-weekly.

b) Crank bearing a little monthly.

c) Clamping mechanism 2-weekly.

d) Clamping caps used to be lubricated monthly, but we had them reamed out .005" (0.13 mm) so that they now require no attention.

Maintenance

a) Any of the inspections that were only done visually should be checked physically - tightening of nuts, etc.

b) After about three years sections of the guideway will require renewing (so far no maintenance has been required on wheels or guide rollers, however when, in about 1 year, bearings or rollers begin to fail we will replace them on the whole 131 units.)

c) Repack crank bearings yearly.

d) Replace clamping jaws when required, (probably after 2 years).

e) Replace phosphor bronze bearings in clamping mechanism when required, (probably after 2 years).

f) Tension track when required.

General Note: The only troubles experienced on this particular section have been:-

OBJECTIVE 2 (contd.)

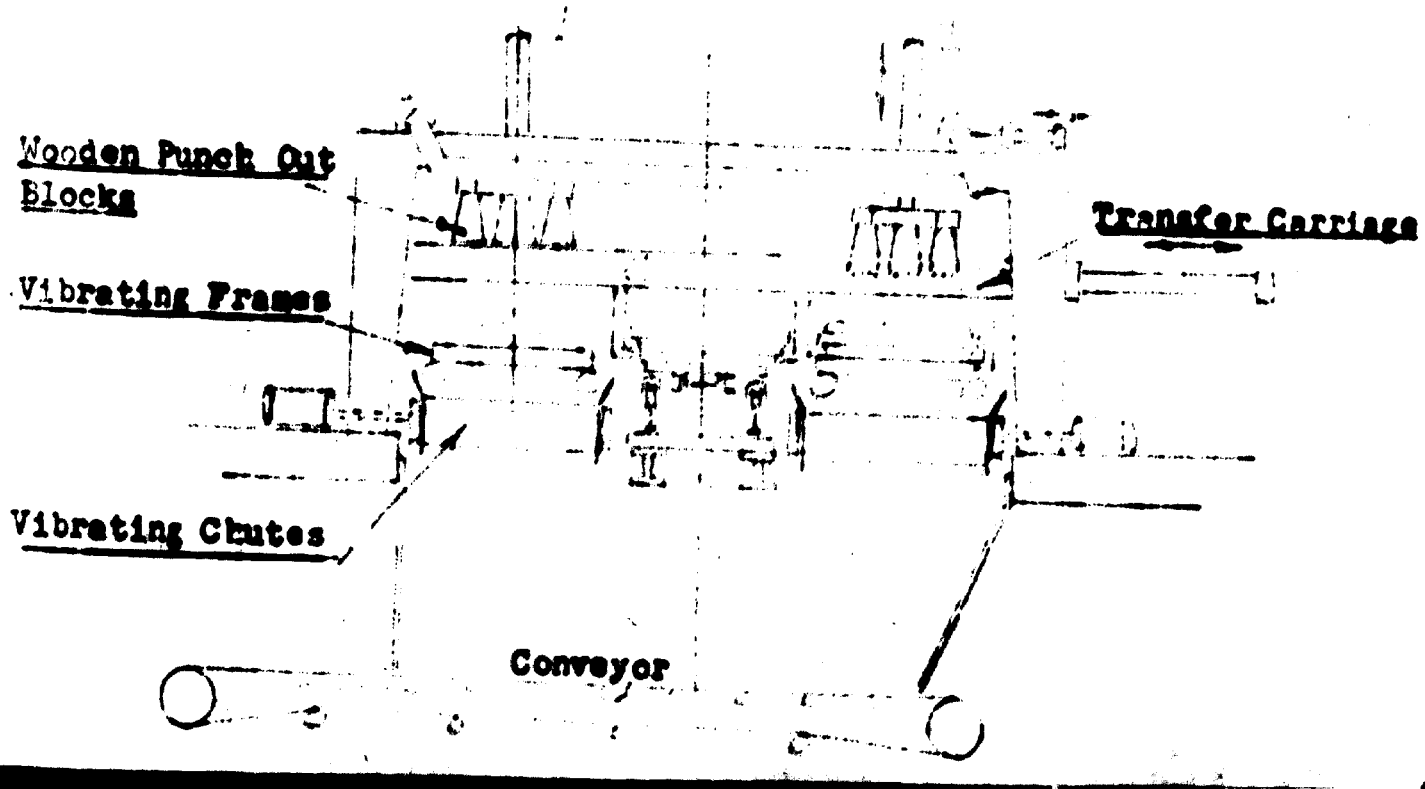
a) lifting of the pallets on the corner marked X, this being due to the particular shape of our track and controlled by correct tensioning at two points.

b) the reduction unit tends to move under the continual strain of the con rod pulling then pushing the conveyor.

c) the bolts connecting the con rod to the clamping mechanism tend to shear under these same conditions. This is being remedied by larger bolts, better location and by setting up at mid stroke.

b) Punch Out Device

This unit picks up a moulded box containing castings from the pallet conveyor, transports it to the punchout position (1) (at the same time it transports an empty box back onto the conveyor from the punchout position (2)); it then lowers the box onto a frame which immediately begins to vibrate. The actual punchout then takes place by forcing three timber blocks downwards, punching sand and casting out of the box down onto the first vibrating sieve. When the blocks are raised again the vibrating ceases and a new cycle commences.



OBJECTIVE 2 (contd.)

Inspection Daily

a) Check wooden blocks for damage, twist or cracking.

b) Check lifting chains and chain wheels.

c) Check slideways for wear or sticking.

d) Check security of nuts & bolts.

e) Check rollers for bearings, wear or damage.

f) Check that vibrating motors are working and are properly secured.

g) Check that wear strips on vibrating frame are in good condition.

h) Check that the lifting feet are correct, i.e. not twisted or damaged.

i) Check proximity switches for position or damage and security of fixing.

Lubrication

a) Bearings on lifting mechanism 2-weekly.

b) Rollers a little 2-weekly.

Maintenance

a) As chains stretch slightly adjust lifting height.

b) Replace wooden blocks as required.

c) Straighten lifting feet as required.

d) Replace wear strips as required.

e) Check inside vibrating motors monthly.

General Notes

The usual problems on this equipment occur due to its rather arduous tasks and the environment that is created at any punchout unit.

The wooden blocks punch about 16,000 boxes of hot sand and castings per week and besides the heat and physical punching, fine sand and steam have to be combatted. Even this would

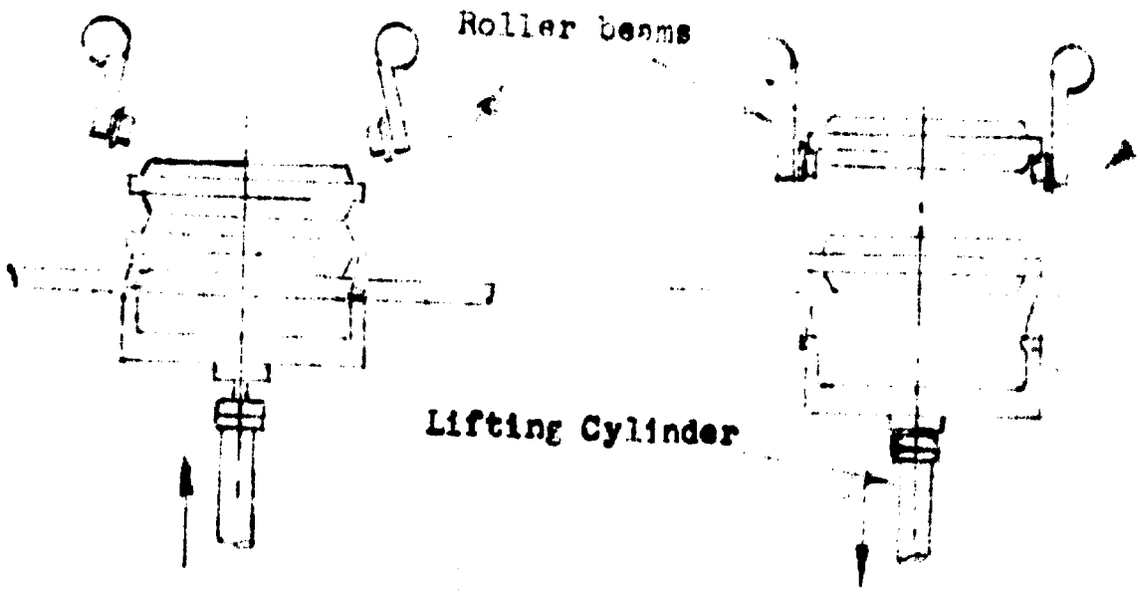
OBJECTIVE 2 (contd.)

prove too much for many pieces of machinery, but the punchout also withstands sudden shock loads and vibrations. As a final enemy the punchout is often subjected to large pieces of metal or castings which can so easily get stuck between the wooden blocks or under the lifting feet.

It can be seen that this equipment must be kept in good condition against tremendous odds which only highlight the need for proper maintenance.

c) Box Lifting, Separating and Closing units

In order to get the copes (top boxes) into the moulding machines and then back onto a matching drag (bottom box) at the other side, we have to lift the boxes, locate them in roller beams and then transfer them through, finally lowering them on the other side. This is done similarly on the drag machines. The lifting is attained by means of a four pin frame, elevated and lowered again by a hydraulic cylinder. Whilst the separation and closing is attained by two hydraulically swinging roller beams, which hold the boxes.



Box Separation

OBJECTIVE 2 (contd.)

Inspection Daily

a) Check for setting of 4 pins.

b) Check security of fixing bolts.

c) Check rollers for wear, damage, bearing failure or security.

d) Check for play in roller beam bearings.

e) Check position, fixing and for any damage to proximity switches.

f) Check that no sand is building up around the vertical piston rod

Lubrication

a) Grease hydraulic cylinder guide rod bushes 2-weekly.

b) Grease roller beam bushes 2-weekly.

c) Re-pack rollers 2-yearly.

Maintenance

a) Replace roller beam bushes approximately 2-yearly.

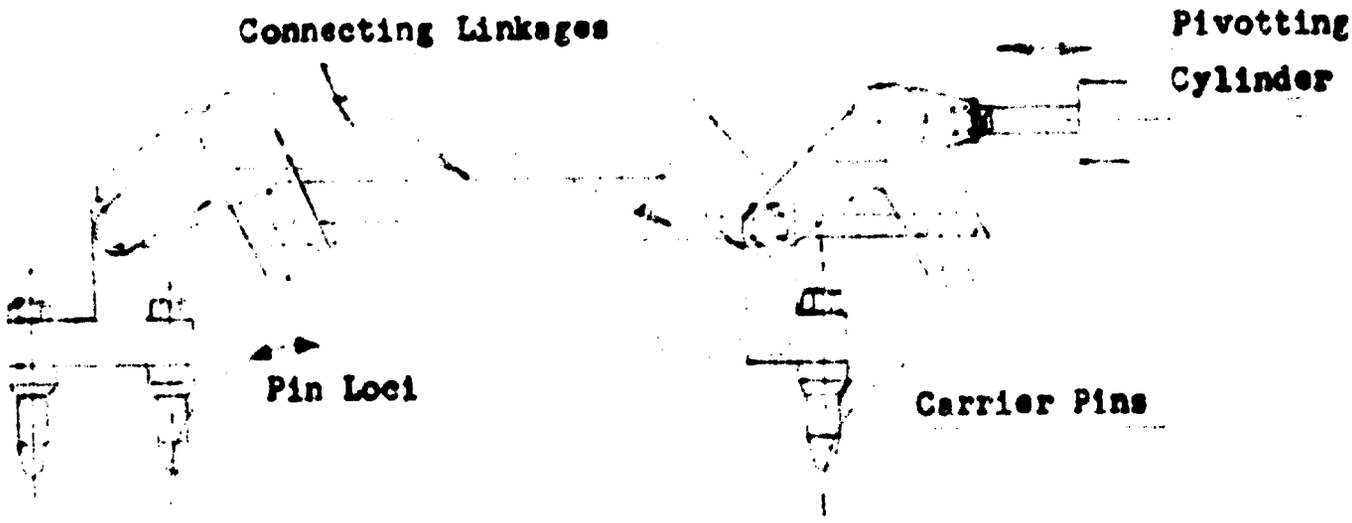
b) Replace rollers or repair as required.

c) Adjust lifting pins as required.

d) Replace guide rod bushes and scraper seals as required.

d) Transfer Carriers

These are used to convey the moulding boxes to and from the machines and are all basically of the same type. Where a pin is inserted into a hole in the box and then the whole unit which is mounted on rollers is pushed or pulled by a hydraulic cylinder.



OBJECTIVE 2 (contd.)

Inspection Daily

a) Check wear on pins and if pins are securely fixed.

b) Check all mechanism for bush wear.

c) Check rollers and guideways.

d) Check welded joints for stress cracking.

e) Check all nuts and bolts for security.

Lubrication

a) Grease phosphor bronze bushes daily.

b) Grease main carrying rollers 2-weekly.

Maintenance

a) Replace pins when box positioning becomes effected or if they are badly worn and likely to be damaged or break.

b) Complete overhaul of the carriers will be necessary 2-yearly for the empty box side; yearly for the full box side.

c) Replace rollers when required.

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9. Moulding Machines

We have two cope and two drag machines all working in an identical manner, the sequence of events being as follows:-

a) Sand hopper filled with sand moves over moulding box.

b) Hydraulic press brings box in position just below sand hopper.

c) Hopper door opens and fills half of the box.

d) Hopper moves outwards filling remainder of box and also brings the squeezing head into position over the box.

e) Hopper door closes and hopper is refilled with sand.

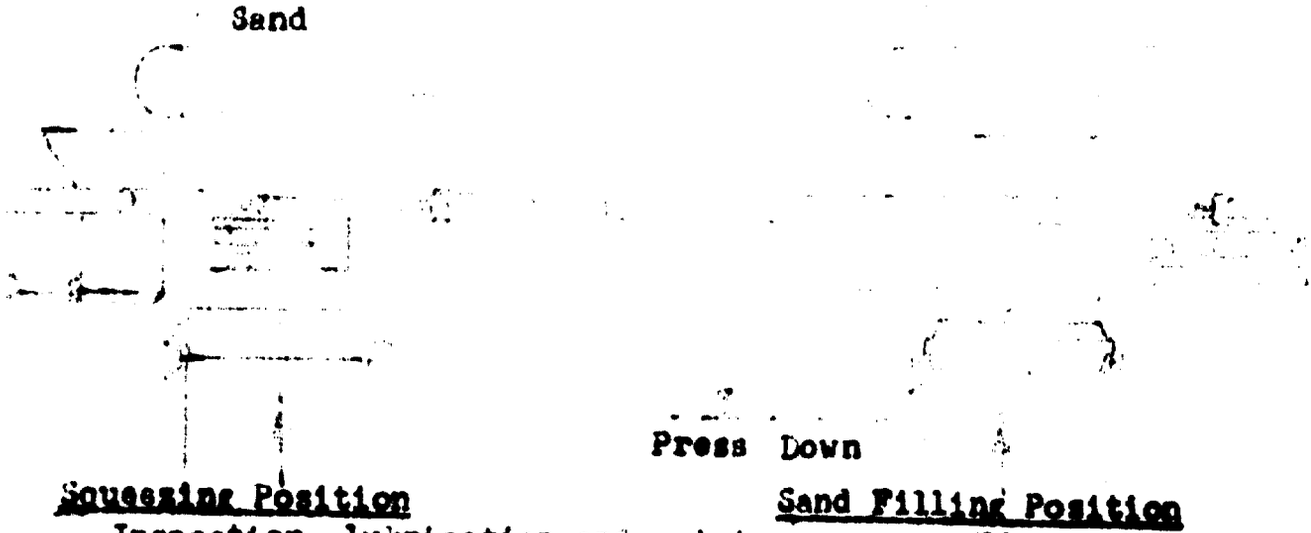
f) Hydraulic press squeezes pattern into sand and sand against fixed squeeze head. At the instant of squeeze the press is jolted to obtain good sand compression.

g) Press moves down quickly, then slowly as the box re-seats on

OBJECTIVE 2 (contd.)

its rollers and as the pattern leaves the sand a pneumatic vibration occurs to obtain a clean draw. Press then falls quickly again except for a final hydraulic cushioning.

h) Moulded boxes are then removed and replaced by empty boxes and a new cycle commences.



Inspection, lubrication and maintenance are all carried out in a similar manner to the previous items of plant i.e. consideration is given to rollers, guides, slideways, security, bearing condition and correct settings. Therefore I will pass on to a few more interesting details.

a) The vibration of the presses which weigh approximately 7 tons each is performed by two small pneumatic vibrating motors, these are only 7½" x 1¼" in diameter and operate by means of a free piston being blown from one end of the short cylinder to the other. One end is allowed to strike a hardened steel end plate whilst the other is constrained by a compression spring, this rapid movement creates the small but necessary press vibration.

Inspection Daily - Check if the unit is working.

Inspection Monthly-Check if the spring is in good condition and if wear is taking place in the cylinder or at the end caps, also check the condition

OBJECTIVE 2 (cont'd.)

of the piston and end caps as they tend to crack up after some months (this is a breakdown of the crystalline structure due to continued vibration.)

Lubrication - is only required in the air line.

Maintenance - Replace springs as required, also pistons and end caps as required. Note! Pistons may last months or years.

b) The press jolting is obtained in a similar manner by a large piston insert and spring, within the centre of the press, air being forced in compressing the piston until the exhaust port is reached whereupon the spring overcomes the air pressure for an instant forcing the piston upwards again.

Inspection - is carried out yearly to see that the insert is secure and separated from the main press casting by a compression ring. (If this were not done the main bolts would be sheared off under the continual strain.) This takes about 1 hour for each press. Another inspection carried out is to check the spring and wear in piston or cylinder 2-yearly. This being a major job taking 4 or 5 hours per press.

Note! This operation is controlled by solenoid operated valves which require normal pneumatic equipment maintenance. (usually only needing a clean out.)

c) The lower portion of the main press body is purely a hydraulic cylinder and requires seal changes only when required as maintenance can be carried out over a weekend and seal leakage on this type of equipment should not become excessive in a short time.

d) The pattern bolsters are held onto the presses by means of

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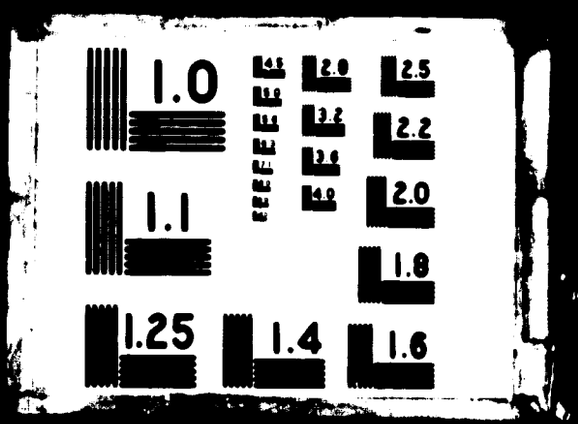

OBJECTIVE 2 (contd.)

electro magnets and are heated by electric elements. We have had no trouble at all on the magnets except where the cable can become damaged and this can be prevented by guarding. The heating elements we only exchanged on failure as it is a simple matter to put new patterns in, and new or repaired heaters to be fitted.

e) The moulding boxes which come to the machine on rollers tend to roll slightly under vibration, therefore each box is located by a pneumatic cylinder before the presses come up under them. This is imperative as if a box is squeezed out of position much damage may result.

Another factor in box location is that if rollers become stiff the boxes will wear a flat on the periphery, this is most undesirable due to:-

1) misalignment creates wear and excess duty on other rollers.

2) if the roller turns a little it tries to rotate back to the flat when the box weight becomes static.

Rollers are therefore replaced or repaired when required. This should be about 1 year for repair and perhaps 3-4 years before replacement is necessary.

Note! When rollers become flattened it is possible to machine them down and re-build or bush them. New shafts should be kept in stock and also bearings.

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OBJECTIVE 2 (contd.)

10. Electric Motors

When decisions on maintenance programme for electric motors the first thing to do is to divide them into sections. For simplicity, two sections will be enough.

Section 1 Motors that do not have any moving electrical connections.

Section 2 Motors that have any type of moving electrical connections, i.e. brushes, slip rings or commutators.

A good programme of maintenance would be:-

Inspection Daily - Sections 1 and 2

Visual inspection - plant running

a) Motor and adjacent cables for physical damage (special care where flexible cables are used).

b) Build up of dust, sand spillage or leakage of liquids onto motor.

c) Check for bearing noise and localised hot spots and in the case of geared motors a careful check for oil leaks.

d) Occasionally it is good practice to check running currents.

Inspection 3-monthly - Section 1

Inspection with motor stopped. Open connection box and check connections for tightness, carry out insulation tests.

Inspection 3-monthly - Section 2

Inspection with motor stopped. Open connection boxes and check connections for tightness. Inspect slip rings, commutators and brushes for wear. Replace brushes as required and adjust spring tension to manufacturers instructions. Carry out insulation tests.

Inspection 2-yearly - Sections 1 and 2

Remove motor to workshops, strip down and clean out,

OBJECTIVE 2 (contd.)

wash out bearings in a non-inflammable solvent, inspect bearings and replace if required, repack with fresh clean grease, replace oil and dust seals. Rebuild motor and carry out resistance and insulation tests. Finally carry out test run.

Before completing this section on maintenance of electric motors it must be remembered that motors which are in store require some simple attention. All that is required is to see that the motors are kept clean, do not get damp and to rotate the drive shaft by hand for part of a turn about every two or three weeks.

Whenever an electric motor does burn out we send it away for re-winding, this, in our case, being economical as we can obtain a normal 3/4 day service or an emergency service of 24 hours locally. Also for all the motors which are essential to the plant operation we hold a spare in stock, therefore the necessity for a re-wind section is reduced.

As a final comment on electric motors I think it necessary to say that whenever electric motors are installed the following points should be considered.

a) Is this the correct type of motor for the duty required.

b) Is this the best method of motor starting.

If these questions are not asked, many consequences may have to be faced such as burn outs, uneconomical power usage, high starting currents, etc. This is particularly true on our type of automatic plant where 32 to 40 motors are started in relatively quick succession and a possible total of 93 motors running at the same time ranging from ⅛ hp. to 150 hp.

OBJECTIVE 2 (contd.)

c) When many induction motors are in use the necessity of power factor correction should not be overlooked. This of course can be improved by correct starting, individual or main capacitors.

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OBJECTIVE 2 (contd.)

11. Speed Reducers, (Gearboxes) clutches & couplings

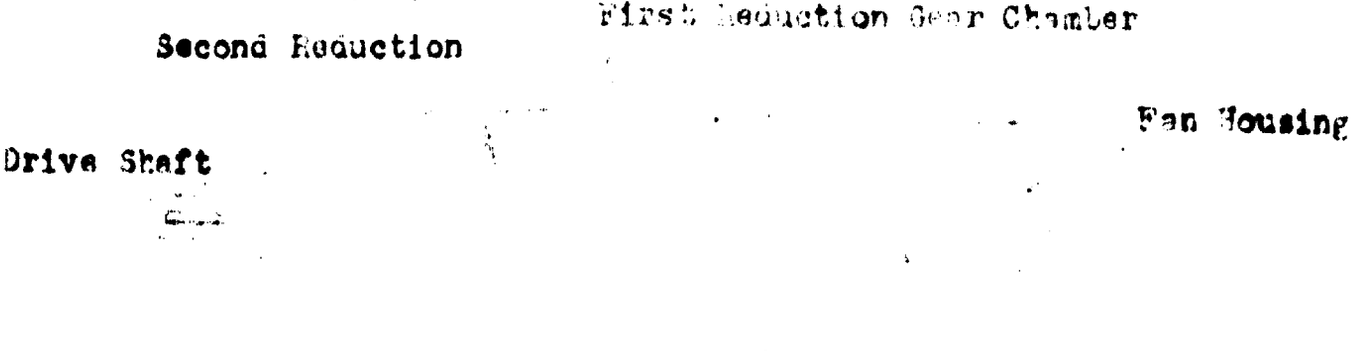
We use three basic types of speed reducers on our plant:-

a) Gearbox mounted direct onto the motor shaft (geared motor).

b) Drum motors which comprise of a drum encasing an electric motor driving direct through an internal gearbox.

c) Reduction gear boxes being driven from an electric motor through a coupling and clutch, a variable speed pulley or vee belts.

a) The majority of our geared motors are supplied by Bauer and are as shown.



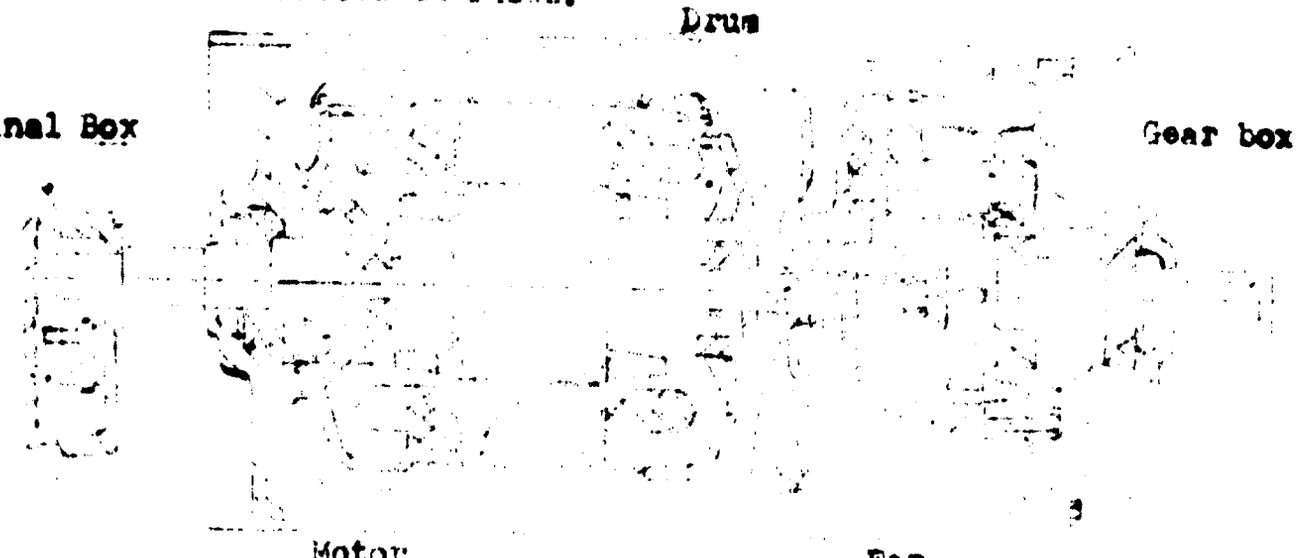
By courtesy of Bauer (G.B.)

Motor

These units require very little maintenance and the only work necessary is to change the grease 1-2 yearly. This should be done using great care and cleanliness using only the specified grease and quantity of grease, taking care to wash all the old grease away. A visual inspection should be carried out whilst this is being done and any suspect seals renewed (after two years this is wise anyway). From my experience the only weak spot on these units is the seal between the electric windings and the gearbox, this should be replaced immediately it becomes suspect or the motor will be seriously affected.

OBJECTIVE 2 (contd.)

b) We use two types of drum motor, Bauer and Himmelwerke, which are constructed as shown.



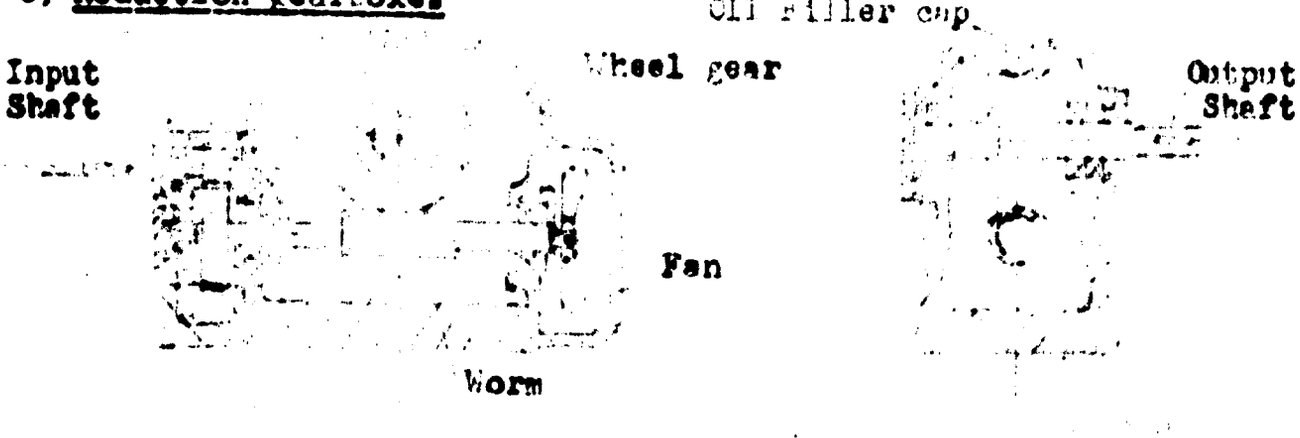
Here again little maintenance should be required on these items, but as they are under a greater strain than the conventional unit, the end bearings have to be inspected daily for any signs of a fault. The utmost importance must be given to the installation of these units, as if they are not properly mounted and if correct journal clearances are not observed a failure is bound to occur. This is because torsional oscillations are set up through the unit.

The end bearings require greasing lightly every 2 weeks and they should be re-packed every 1-2 years.

The gearbox should be inspected and re-filled at the same time. Above drawing by courtesy of Himmelwerke.

Note! It is wise to change all seals when doing this.

c) **Reduction gearboxes**



OBJECTIVE 2 (contd.)

Reduction gearboxes of the conventional type are usually lubricated from an oil chamber, the gears themselves splashing the oil around. It is normal to have a sight glass on these and the level should be checked daily. In most cases the correct oil level is midway on the sight glass when the unit is cool, therefore it may be misleading to check when the unit is running as the level could still be low whilst appearing satisfactory.

If properly aligned, lubricated and used for their recommended duty, gearboxes should run trouble free for years. When trouble does occur the symptoms will be one or more of the following:-

1) play in either the drive or driving shaft
2) leaking seals and loss of oil
3) noise
4) heat
5) vibration

When any of these symptoms arise, inspect the unit internally as soon as possible or irreparable damage may be caused. The fault may be, if you are lucky, just a seal failure and as long as no foreign matter enters the gear chamber, this is easily and quickly re-serviced.

However, if metal clad seals or bronze bushes are damaged the whole unit should be stripped.

Shaft play laterally may be due to a collapsed or worn bearing, in which case the gears will soon be damaged if the unit is not taken out of service and stripped.

Any of the above, lack of oil or general long service will eventually cause gear wear; the affected gearing should then be replaced. If any gears are left in whilst adding new gears be absolutely sure that they are serviceable.

OBJECTIVE 2 - (contd.)

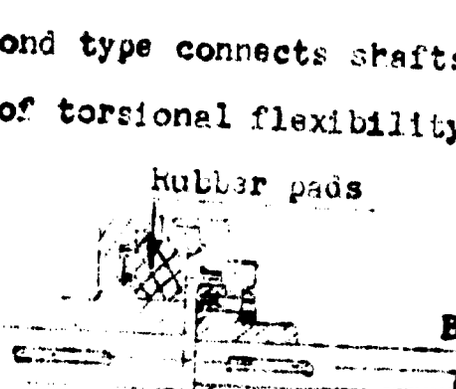
When overhauling any gear box be sure that it is cleaned out scrupulously, assembled and aligned with great care and filled with the correct lubricant.

Couplings

There are many types of coupling and it is very important that the correct type is chosen for the application.

a) The first type is simply to connect shaft A to shaft B which are running on exactly the same axis and not requiring any degree of flexibility or torque protection.

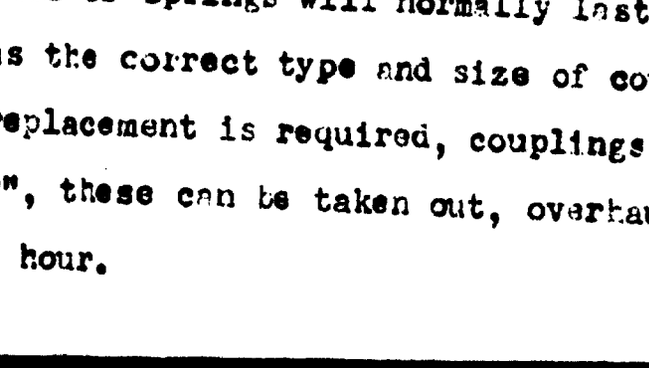
e.g.



For this type the only maintenance required is to check and replace the connecting bolts, also keys.

b) The second type connects shafts A and B but desires a small amount of torsional flexibility, or alignment flexibility.

e.g.



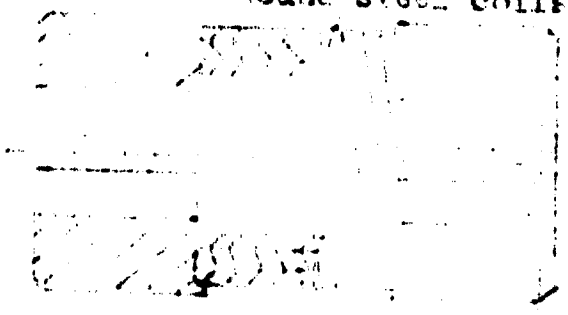
There are many types on the market but most utilise rubber pads or coil springs to allow flexibility.

Inspect regularly and maintenance is very small. The rubber pads or springs will normally last 5 years or more as long as the correct type and size of coupling is selected. When replacement is required, couplings for shafts up to about 2", these can be taken out, overhauled and replaced in about 1 hour.

OBJECTIVE 2 (contd.)

c) The third type is where shafts A and B are not on the same axis.

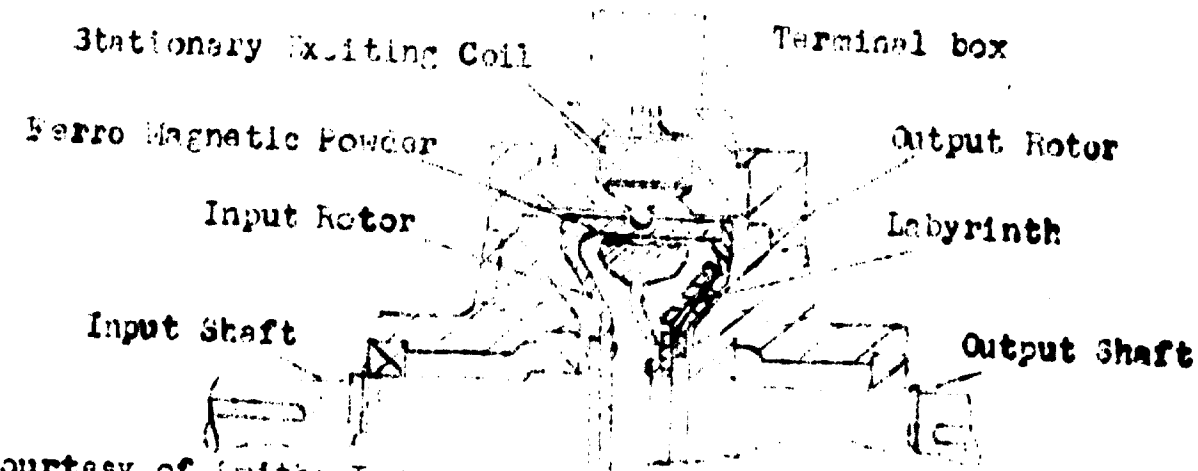
e.g. 1



e.g. 2

Here again as long as they are correctly chosen, maintenance is almost non-existent, but regular inspection should take place, especially where nuts, bolts, bushes or keys are used.

d) Much more important in this age of modern automatic machinery is the fluid or magnetic clutch. These are used for equipment requiring quicker and easier engagement or disengagement, requiring the transmission of greater torques and requiring a unit able to fit in with an automatic process.



By courtesy of Smiths Industries Ltd.

The fluid or magnetic particle coupling is an excellent method of transmitting power whenever a slipping condition is desirable or under the normal type of operation. Since the magnetic particle coupling works on precisely the same principle as a fluid coupling, I shall only discuss this type with regard to operation and maintenance.

OBJECTIVE 2 (contd.)

These couplings consist of a stator housing, stator coil, input rotor, ferro-magnetic powder and output rotor (as shown in sketch), together with suitable electrical control units (this will vary dependent upon the requirement and upon electrical supply and signallsation.)

The principle of operation is based upon the fact that a ferro-magnetic powder is similar to a fluid and in fact is more likely to prove constant over a period as it is not affected by heat, humidity, age, etc. It also has the added advantage that the apparent viscosity of the working medium can be varied by adjusting the flux density of the magnetic field. Since the medium is a powder it is always dry and always of a known consistency. Therefore these couplings can work in an accurately selected manner, i.e. no drive, slipping drive or any given torque transmission, solely dependent upon the excitation current, up to a no loss full drive condition.

Maintenance required is minimal necessitating only inspection of general operation, electrical connections and controls and normal bearing inspections. This should only be necessary on a weekly basis but over inspection is easy when other items are to be inspected nearby.

Bearings are usually sealed for life and therefore under the normal smooth running of this type of coupling require a grease change every 2 years.

A yearly strip down is advisable but since wear is negligible, there is little to go wrong.

Clutches and clutch/brake units may also be found on the open market in abundance and the same priority must be given as with couplings, i.e. assess the duty required.

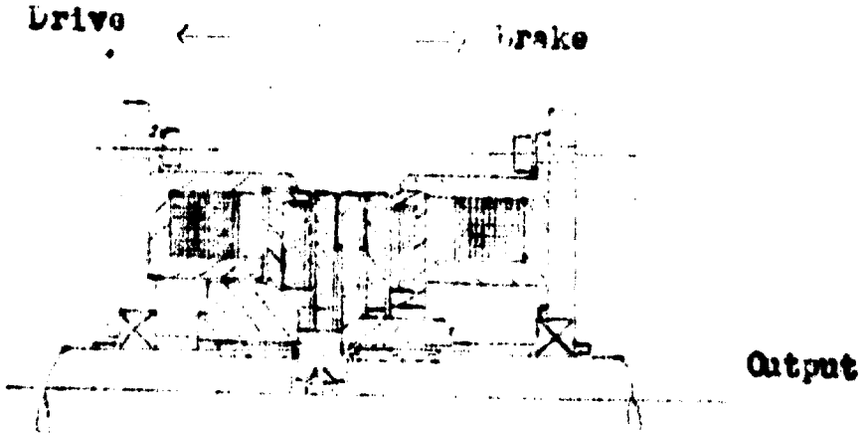
OBJECTIVE 2 (contd.)

Of the many types I will just mention a few:-

a) "dog" or "castle" clutch - these are found on equipment such as lathes when the operation is a relatively slow one and usually by hand.

b) the "ratchet" type of clutch - again usually found on manually operated equipment.
This type of clutch will require more often than not a regular replacement due to wear, the life being dependent upon its duties.

c) Another very popular type of unit is the disc brake/clutch unit. This is able to fulfil the requirements of our particular plant where we desire a very quick and positive action. It functions as follows:- The electric motor is running continually; as soon as we require an output from the drive, current magnetises the clutch half of our unit, thus pulling the drive disc along splines on to the face of the rotating disc. Because we need an immediate response to stop the output shaft at once, the current is at a given signal reversed and current passed to the magnets in the brake disc half of the unit, thus the motor continues to run whilst the output shaft stops dead. When the plant is not in use the centre disc is self centreing.



OBJECTIVE 2 (contd.)

Inspection should be regular checking for immediate response, temperature, noise and chatter whilst running. When stopped the clearances should be checked, in our case each air gap should be between 0.2 mm. and 0.6 mm. because this is a fairly wide tolerance resetting of this unit is only required about every 3 months and a yearly skim of the disc faces may be required to keep it in first class condition, i.e. true the faces by taking off a minimum amount (in our case a total of 0.5 mm. off four faces.)

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Environment

In order to assess the life of any piece of equipment and to decide when and how to maintain it, the two essential factors are:-

a) What duty has the equipment to perform?
b) Under what conditions must it work?

In this short section of my paper I want to mention various environmental conditions that greatly affect equipment and I will use a few typical examples to show their effect. It is also my intention to show that most faults, whatever their cause, can be eliminated by correct maintenance or " designing out", and if

OBJECTIVE 2 (contd.)

not eliminated, controlled sufficiently to make them economically workable.

The major problem to maintenance in the foundry is Dirt and Dust, because it is impossible to have a foundry clean as a machine shop may be classed as clean.

The difficulty is that so much dry, fine sand becomes suspended in the atmosphere, some tends to remain suspended where heat or strong air currents exist, but the majority finally settles in every little corner of the plant.

Piston rods, rotating shafts, slideways, phosphor bronze bushes, bearings - all of these and many others are items of machinery which rely upon their accuracy, their smoothness of operation and they become a prey to the searching particles of sand.

This type of machinery usually has a thin film of lubricant on it, as does the piston rod and this tends to increase the problem by encouraging the dust to adhere to the surface. Under these conditions it is of extreme importance to guard your equipment and there are two ways of tackling this:-

a) endeavour to prevent particles reaching vulnerable parts

Examples:- Seal bearings with dust caps,
Seal bearings and bushes with regular lubrication,
Change greases where possible to graphite or similar,
Fit telescopic guards on pistons when suitable,
Design wiper seals to keep equipment clean,
Fit guards around equipment if they can be totally enclosed
Design dust extraction to suit your needs,
With regard to lubrication, where possible it can be of great value to fit automatic pressure greasers. I use one to lubricate our 4 main

OBJECTIVE 2 (contd.)

presses, it supplies approximately 4 cms^3 at a set pressure at any set time, in our case every 40 minutes. By using this method, dust or dirt are continually forced out of areas in which they could cause much damage.

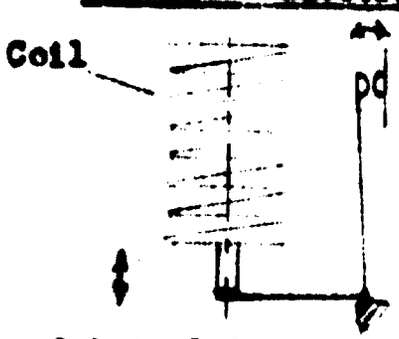
b) inspect, maintain and "design out"

Examples:- Exchange seals as soon as wear shows,
Clean equipment down as often as possible,
On replacement buy, when possible, equipment more suited to the particular situation,
Redesign existing plant to stand up better.

All the above comments are concerned with mechanical plant but do not think that the electrical side is free from problems. Any item having moving contacts is prone to trouble unless extremely well designed with self wiping action or totally enclosed and air-tight.

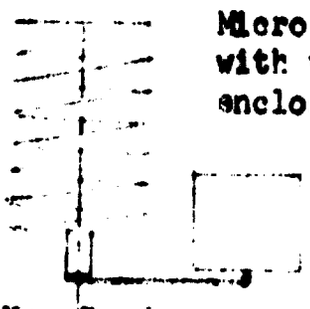
This electrical problem may be alleviated somewhat by having all the controls and instruments in a slightly pressurised cabinet. Even when this is done some dust will enter and so it is wise to have regular inspection and maintenance. In our case we vacuum clean our cabinets and equipment daily. We also use small spatulas to clean all contact points regularly.

Example - Electrical



Original Design

Open contacts prone to ingress of dust.



New Design

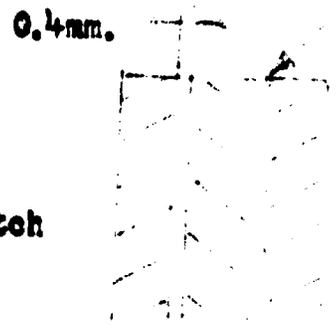
Micro Switch with totally enclosed contacts

This particular piece of electrical equipment was causing us concern as it stops the whole automatic sequence at mid-cycle

OBJECTIVE 2 (contd.)

when the contacts fail.

Example 1 Mechanical

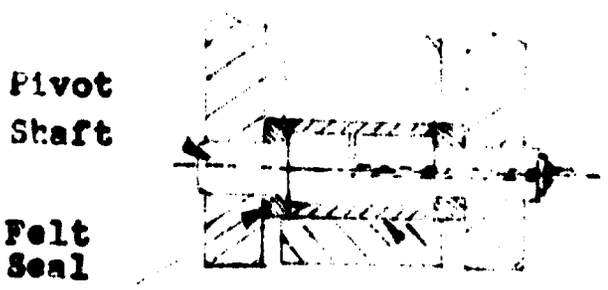


A simple fault easily prevented by a shield.

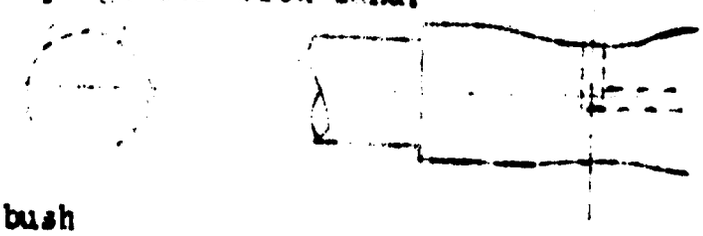
Ground Position

A partially unprotected electromagnetic clutch/brake unit failed to operate quickly enough when a sudden fall of sand from above caused braking to be insefficient. The result being that the plant stopped in an incorrect position, which took 20 mins. to put right on a manual panel.

Example 2 Mechanical



Shaft after 12 weeks running.
Bush only slightly worn, but impregnated with sand.



Phosphor bronze bush

Assembly

This joint which rotates through 100°, 20,000 per week appears to be of a reasonable design for most circumstances, but under foundry conditions was totally inadequate even when greased 3 times per day. At the moment we have not yet redesigned this equipment, due to it being imperative to the operation of the plant the manufacturers are dealing with the problem (this will effect other plants of course).

However there are many ways of improving the life such as changing the shaft material , changing the seal material, redesigning the grease groves in the bush, etc., or automatic greasing.

OBJECTIVE 2 (contd.)

Heat in a foundry is again unavoidable in certain areas and in these areas problems will be encountered. It is always possible to extract some heat but invariably much will remain, especially where radiant heat is involved (as most of you will know radiant heat cannot be dealt with by fans etc., only by physical shields).

Therefore we can extract, shield, or make sure that we purchase equipment which will stand up to the conditions (or modify it to suit).

Example 1 Electrical

On our metal supply runway we use copper bus bar conductors which continually expand and contract, this causes problems as the bars tend to bow, thus making pick up collectors lose contact.

This we have almost eliminated by guarding, adding more supports and adding more insulators.

Example 2 Electrical

The static switching blocks are designed to withstand a maximum working temperature of 112°F or 45°C and on being subjected to this kind of heat become unreliable or fail. In the summer months, we have occasionally experienced this kind of temperature as the cabinet is normally closed and it is situated about 3 metres above a hot casting conveyor. When blocks do become unreliable there is a grave element of danger on the operation of the plant.

The answers to this problem are two fold:-

a) We are putting extraction on to the casting conveyor.

b) If this fails to remove sufficient heat next summer we will pressurise the cabinet with cool air.

OBJECTIVE 2 (cont.)

Example 1 Mechanical

Various gearboxes are used in a hot environment and in these cases we usually contact the manufacturer and also lubricant suppliers to obtain a more efficient protection. Also more inspection is given to these items.

Example 2 Mechanical

The operation of hydraulic valves is impaired by the high ambient temperature, e.g. springs become weak sooner, spools tend to stick due to their extreme accuracy.

In this case little can be done except to put a cooler in the hydraulic circuit and to ensure adequate ventilation where valves are situated.

Whilst on the subject of heat, in a foundry where sand is damp and castings hot it is impossible to prevent steam being given off and just as impossible to stop condensation. The effects of steam are that rusting becomes a big problem and also that when it comes in contact with sand lying on machinery etc. the result is sludge. Sludge has the same destructive properties as dry sand but in addition can be very slippery and dangerous if it gets onto walkways, handrails, etc.

The only ways to tackle this problem are to:-

a) Protect steelwork, ducting, fans, etc. by paints or by using non-ferrous materials.
b) Clean the plant often if possible.
c) Provide adequate extraction.

Vibration

There are many strengths and frequencies of vibration on our plant, some desirable, others objectionable, but all provide problems, problems which in the main cannot be prevented, only guarded against.

OBJECTIVE 2 (contd.)

The most common faults are:- loose nuts and bolts, wear, stress cracking of welded joints, cracked or broken springs, cracks in machine castings, machine beds become loose, items that rely on their accurate positioning may be out of position, electrical contacts may instantaneously lose contact.

Most of these faults can be guarded against and machine failure prevented as long as your inspection is good, your planned replacement correct and your rectification swift. For instance, nuts and bolts should be tightened immediately and should this be insufficient, a new method of locking must be found, perhaps a spring or tab washer, a lock nut, or maybe the application of a locking agent such as LOCTITE (properly applied).

When wear takes place decide:-

Is it reasonable for it to wear there?

Is it wearing more than you would expect?

Is it better to wear there than somewhere else?

Can a better method or material be used?

When springs or rubber pads are used, inspect regularly and exchange parts as soon as weaknesses are found.

To prevent excess vibration and the effects of vibration on other plant:-

Isolate each item where possible.

Never connect vibrating plant to the main plant or building structure.

Put machinery on anti-vibration pads.

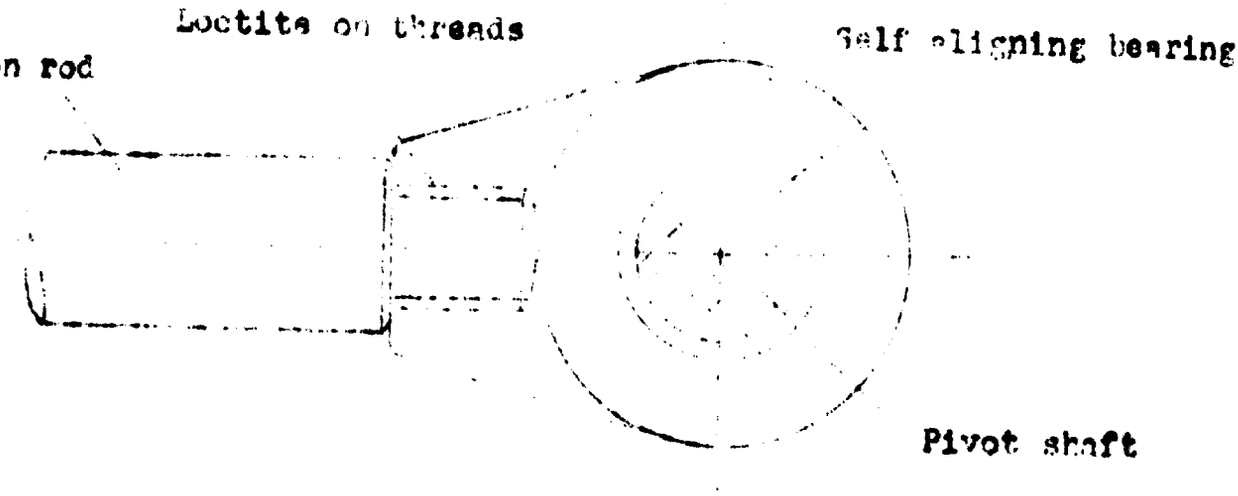
Example 1 Electrical

On automatic machinery the use of limit switches and proximity switches is numerous and as the majority of these require a bracket to hold them, ensure that if it is reasonably

possible, they are both bolted and locked (even tack welded) in position. Otherwise signals may be non-existent or incorrect due to loose brackets or wires torn out, etc.

Example 1 Mechanical

Where threaded joints are used on plant having to withstand banging or vibration, it is wise to provide some means of locking. Where we use hydraulic cylinders we LOCTITE the piston rod into the end bearing, this is because once a joint becomes slack the threads are stripped off in a very short time, due to the relative axial movement between male and female thread form.



Example 2 Mechanical

On vibrating chutes the wear plates and strips should be both welded and bolted, so that when stress cracking occurs, (which is quite often under severe conditions) the plates do not get the opportunity of vibrating into a dangerous area or to render the chute irreparable by severe damage.

Example 3 Mechanical

One of the features of our moulding plant is the vibrating of the pattern on withdrawal from the newly made mould, the pattern plate being secured by a bolster directly onto the mainpress. These main rams weigh approximately 7 tons each and yet the vibration is achieved by two very small diametrically

opposed, pneumatic cylinders, which measure approximately 180 mm. long x 35 mm. inside diameter. They simply contain a freely moving piston 160 mm. long x 35 mm. outside diameter and one small compression spring and operation is obtained by passing air through two ports drilled from either end of the piston, the inlet ports being radially drilled and situated about 20 mm. apart. When air enters the cylinder through one fixed port the piston very rapidly moves from end to end under the force from the compression spring and alternating air feed. The end which has no spring acts as an anvil and the vibration is the result of this hammering effect.

The springs in these vibrators have to be replaced at 2-monthly intervals as they break up after this time.

The end caps of the cylinder and the piston itself were made of a hard casehardened steel, but they tended to crack after a few months use. At the moment we are experimenting with soft casehardened steel as we feel that the crystaline structure breakdown should not occur to the same extent, however we appreciate that wearing may now take place.

Wear

This is not an environmental cause which effects equipment but it is the after-effect of a general foundry environment and therefore it deserves a special mention.

Besides the wearing caused by dirt, dust, rust and vibration we, in the foundry industry, have to deal with the very arduous task of transporting items such as moulding boxes from one point to another, up, down, to and fro, day in day out. Our moulding boxes are of a medium size and weigh just over ½ ton when full of sand. In general we transport them on stub rollers

OBJECTIVE 2 (contd.)

or by lifting beams and in some places they are required to stand whilst being vibrated and in others whilst they are located.

Our rollers have to be kept in good condition because if they become stiff the boxes will wear f ats on them rendering them useless.

The lifting beams become worn by continual friction and must be replaced or repaired before inaccuracy of movement occurs.

Locators have to be hardened to stand up to the cast steel box surface and are designed for easy replacement.

When dealing with such mechanical problems as these it is sometimes easy to forget to ask the question " is it better for this part to wear then something else". Instead we try to prevent wear but only succeed in creating another problem.

Example 1

Our moulding boxes are located using nitrided bushes and case hardened pins but in two cases these boxes are transferred using similar pins which locate into a hole direct into the cast steel box. In this instance the pins require changing or repairing every 4 months but it is much more economical to replace pins then to use harder ones which would wear the moulding boxes.

Example 2

In our punchout unit the moulding boxes are placed on a vibrating frame to be punched out and also to remove loose sand from the boxes. Once empty they tend to move on the vibrating frame causing wear. Now if a hard steel frame were used the moulding boxes might wear instead or due to the lower friction coeficient the boxes might be vibrated beyond the accuracy required, therefore we use nylon or a similar material inserted

Objective 2 (cont'd.)

into the frame. This gives improved friction coeficient, equivalent wear and easy replacement.

A final problem found only in our type of industry is Molten Metal. When pouring moulding boxes it is possible for quite a large quantity of molten metal to be spilt onto the equipment, also metal which falls through more than a few inches (centimetres) splashes in the same manner as mercury splits up into separate globules.

The first instance involves high temperatures and the difficult problem of dealing with a fluid substance. Our main troubles are:-

a) At the pouring section the continual requirement to provide adequate protection to both the production personnel and the plant itself. This is done in the form of replaceable steel sheeting mounted on a tubular frame.

b) Metal which pours between the shield and the plant builds up sometimes on the main track of the moulding box conveyor and if this is not removed regularly the conveyor begines to jump at that point and would in fact leave the track if it were left too long.

c) Metal which pours between the separate pallets on the conveyor builds up on a strengthening plate beneath and has to be cleaned regularly to prevent faulty clamping or declamping. Here also this metal must be prevented from damaging the guide roller bearings due to heat and deflection plates or guards must be used for this purpose.

d) Smaller pools of metal which solidify become like wedges or chisels continually damaging hydraulic cylinder seals,

OBJECTIVE 2 (contd.)

preventing the boxes from rolling freely, giving false signals to proximity switches, marking the aluminium patterns and so on.

Many of these instances will only be applicable to our plant but some and probably more will occur on other plants, therefore it is wise to give thought to the prevention of damage before excess maintenance is created.

.....

Fault Finding and Re-Commissioning

To conclude this section, I have spoken about how and when to maintain or repair but I have not said much with regard to actual procedure when breakdowns occur or when a technician or operator notices something wrong on his inspection.

Whenever this situation occurs it is my opinion that the procedure and approach should be as follows:-

1) The skilled personnel must decide - Can I rectify this quickly and on my own? If so, he should do so.

2) If he cannot correct a fault on his own he must summon one of my assistants, myself, or if the fault is found by a mechanical man but thought to be electrical, call in an electrician and vice versa.

3) If the fault cause is not easily seen, the personnel should quickly decide what course of action they will take and then logically proceed to find the fault. If two main trains of thought are encountered then the supervisor must decide which course to follow or whether it is possible to attack the problem from two angles.

OBJECTIVE 2 (cohtd.)

Example 1

Symptom - Box has not been lifted from A to B for some unknown reason in the automatic cycle.

Evidence at hand

1) The mimic diagram shows that the passage is clear and that the solid state modules are signalling for the box to be lifted.

2) There is no apparent jamming or blockage physically.

Logical approach

Step 1) Will box lift on electrically controlled manual operation? - NO

Step 2) Will box lift on manual over-ride? - YES

1st Conclusion

Electrical fault between signalling block and solenoid.

Step 3) Test wiring for continuity - ALRIGHT

2nd Conclusion

Solenoid fault either failure or electrical connection.

Step 4) Open terminal box. This may show a loose connection or broken crimped connection or possibly spark erosion may have taken place due to condensation in the terminal box.

If this is not so, exchange failed solenoid.

Example 2

Symptom - As before

Evidence - As before

Logical Approach

Step 1) - As before - NO

Step 2) - As before - NO

1st Conclusion

Mechanical or more likely hydraulic fault.

Step 3) Check for feel of the over-rider operation, (if one side is stuck this can be felt). If incorrect strip pilot block. In this case the fault would probably be sticking due to dirt in the system or excess heat.

Step 4) If Step 3 is carried out but no fault found then the fault may be the spool speed regulator, the main spool sticking or one of the spool springs may be broken. These are checked in the reverse order as they can be checked as the valve is stripped further.

These are two examples of finding faults which can occur ..... regularly; if your staff do not approach a problem in this way then in general your downtime will be excessive as the only other way would be to guess.

Note! They are purely examples and I appreciate that there could well be other causes such as air locks or failure of a throttle non-return valve.

Just as important as locating a fault or repairing the equipment is the re-commissioning of that equipment and therefore it should be made plain to all personnel that before handing the plant back to production it must be tested to prove it as far as possible operational.

Objective 2 - What, when & how to maintain

Sand Plant

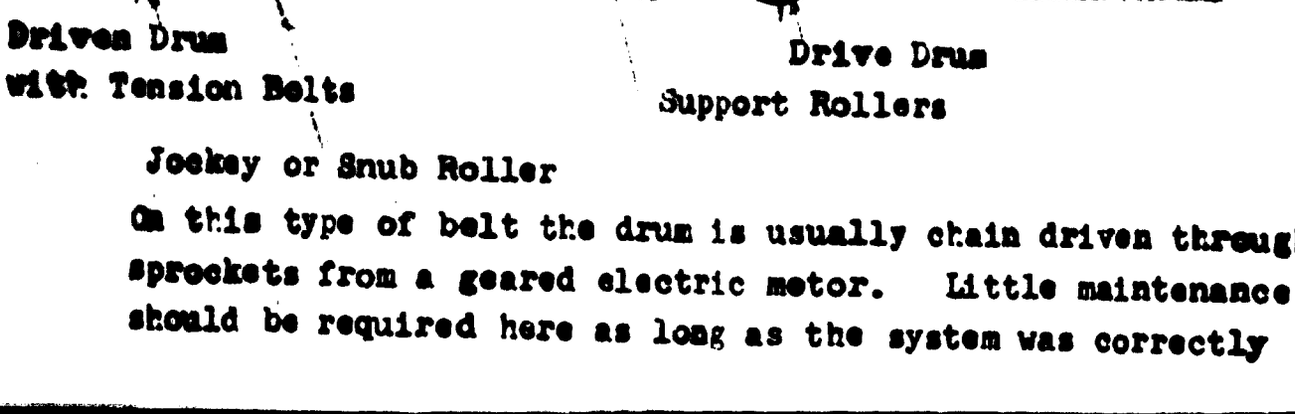
The major part of any sand conditioning plant is taken up by the sand storage hoppers; these, however, require very little maintenance for many years and then it is most economical to renew whole sections. It is wise on installation to have these hoppers coated with rust and abrasive resistant paints or resins of which there are many on the market and by doing this, maintenance for 3-5 years is purely a matter of inspection for rust or wear and a random check on nuts and bolts (this is in our case done to some extent daily).

One word of warning on hoppers or any other equipment holding sand which must flow, if sand should tend to stick due to high moisture or on oil slicks, etc. do not use hammers on the wall to free the sand, this only makes the problem a permanent one by denting the sides thus creating an obstruction and a grip. Where sand sticking becomes a problem, wrapping plates can be secured to the side and these may be hammered freely. Another possible cure is to attach a pneumatic vibrator to the hopper wall or in certain cases it may be economical to treat the face with molten glass or p.t.f.e., thus reducing friction to a minimum.

Conveyor Belts

There are two main types of conveyor belt.

1. The first is the flat belt conveyor which is usually used in the form of a "drag out" belt, i.e. where large quantities of sand are stored directly on the belt in a large hopper and where the sand is dragged out under a gate of fixed height. In this case the conveyor is constructed as shown.



On this type of belt the drum is usually chain driven through sprockets from a geared electric motor. Little maintenance should be required here as long as the system was correctly

designed to take the maximum sand weight. Most geared motors simply require checks on oil/grease level, motor current, cleanliness, temperature and secure fixing. With respect to the chain drives these should be checked for secure fixing, alignment, wear, chain tension, also realising that the chain should be slightly lubricated and that the guards should not harbour sand. If sand congregates on or near a chain drive get rid of it and prevent it occurring again. The main drums themselves will require lubricating normally once per week and otherwise only need to be kept free from hard sand buildup, this being easily done by scrapers.

For the support (weight conveying) rollers, these should be fitted very close together to prevent excessive load on each roller or the belt spanning the rollers. If this is not done, bearings will soon collapse, belts wear and excessive sand spillage occur. In general these rollers will have enclosed "lubricated for life" bearings, which should be given a small amount of lubricant about every 3 months and the whole grease packing exchanged after 1-2 years.

The jockey or snub rollers are most important and affect the tracking and running of the belt enormously, they give a good arc of contact grip for the belt over the main drums and also help to keep it running true. The bearings may be normally sealed and greased about 2 weekly or sealed for life as above.

Similar maintenance is required for the return rollers which simply take the weight of the belt on its return preventing flapping and stretching due to sag.

For a rubber belt conveyor to run economically it should be correctly tensioned, correctly tracked, have its side skirtings correctly adjusted to prevent sand spillage, its scrapers adjusted and also be regularly inspected for cuts, holes, lifting

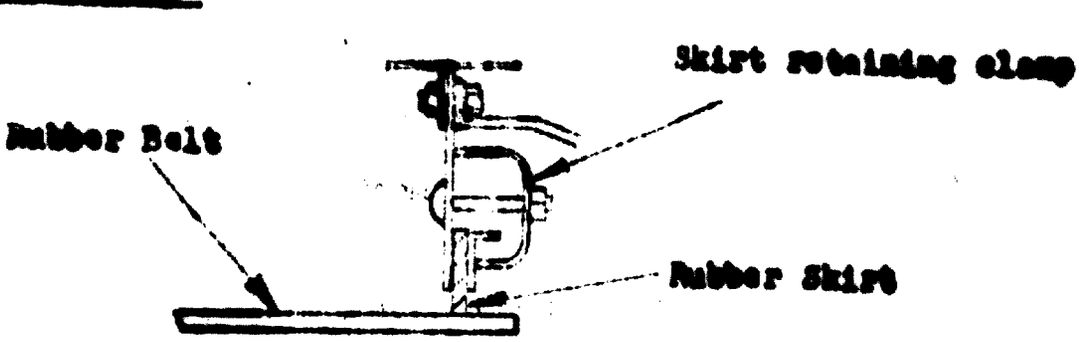
joint, pieces of foreign matter embedded into it, burns and general wear due to abrasion.

Tensioning is very easy to do but requires experience to know when the belt is correctly tensioned. It is an extremely difficult thing to explain in writing out as a guide I should say that if on the return (under) side of a rubber belt conveyer the belt is supported by rollers spaced 1500 mm apart, then when the belt is stopped, there should be a free vertical movement of the belt by hand of about 50 mm.

Tracking - this is not as easy as it first appears, the first thing to do is to use the tensioning bolts to get the belt running true under no load conditions, then under loaded conditions; now due to the varying loads or direction from which the sand comes may cause the belt to wander and this must be cured by the jockey roller or the tension bolts only. (Note! this is only true for a "drag out" belt).

For a new belt it will take at least one or two days for the initial elasticity to be taken up and during this period constant attention to tensioning will be required, however it may take one to two weeks to finally get an awkward belt running true.

Side Skirtings



This aspect is extremely important to the sand spillage and hence plant cleanliness point of view, but also a slack skirt may allow loose sand to fall between belt and driven

drum to cause tracking problems. On the other hand a skirt which is too tightly pressing on the belt will cause wear (usually doing serious damage to the belt over a period).

Belt inspection can be a very difficult task where belts are inaccessibly placed, but this is one of the most important jobs if production is to be left unaffected. In our case if virtually any belt fails for any reason then the whole plant will come to a standstill within a matter of minutes. I have already mentioned what to look for, the problem is what to do if a failure occurs. From our point of view we always have:-

1) a spare belt available but this will take about 12 hours to be ready for running by correct vulcanising, or up to 6 hours if an endless belt can be fitted.

2) a belt stitching machine for emergency repair (this depends upon the nature of the failure).

3) rubber solution, filler and patches.

It therefore becomes your decision to close down or to do the emergency repair.

With regard to frequency of maintenance and inspection:-

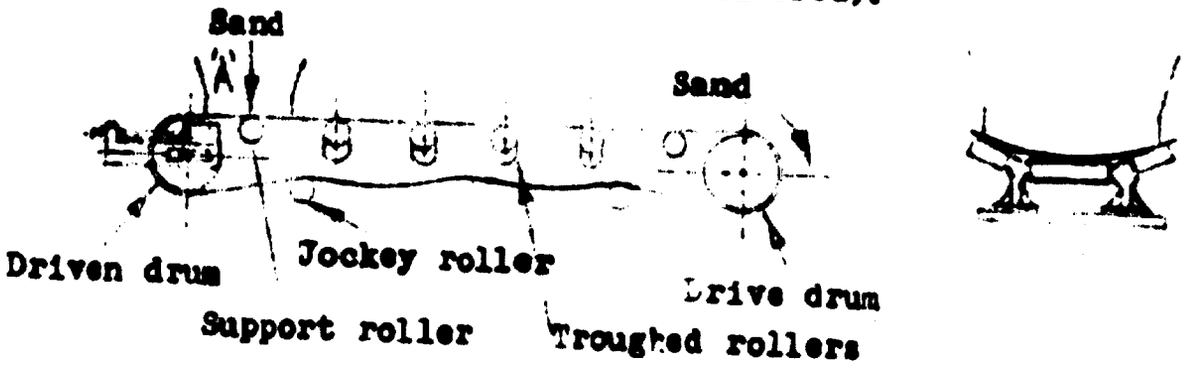
1) lubrication as stated,

2) general mechanical and belt inspection daily,

3) chain and sprocket check monthly.

2. The second basic type of rubber belt conveyor is the "troughed type, this being used for general movement of sand from or to equipment, bucket elevators, overflow hoppers, etc. Here no excess weight of sand is met, so we trough the belt to reduce spillage and to centralise the load for delivery,

the problem of tracking also being eased by centralisation, (not true if large loads are delivered).



The differences here from a "drag out" belt are that except for approximately (dependent on duty) 1 roller just after and just before the driven drum, all the other rollers are troughed and need only be spaced suitable to the load they must carry. For instance, if sand is delivered to it at "A" then the rollers will be say 9" centres but then for the rest of the belt 18" centres will probably suffice (this depends on each individual case and may be decided upon by experience, calculation, trial and error, or by contacting belting experts).

Also due to it having a less arduous task the belt may well be driven by some other means than chains, in our case drum motors. Lubrication, maintenance, inspection will be precisely as before, the exception being:

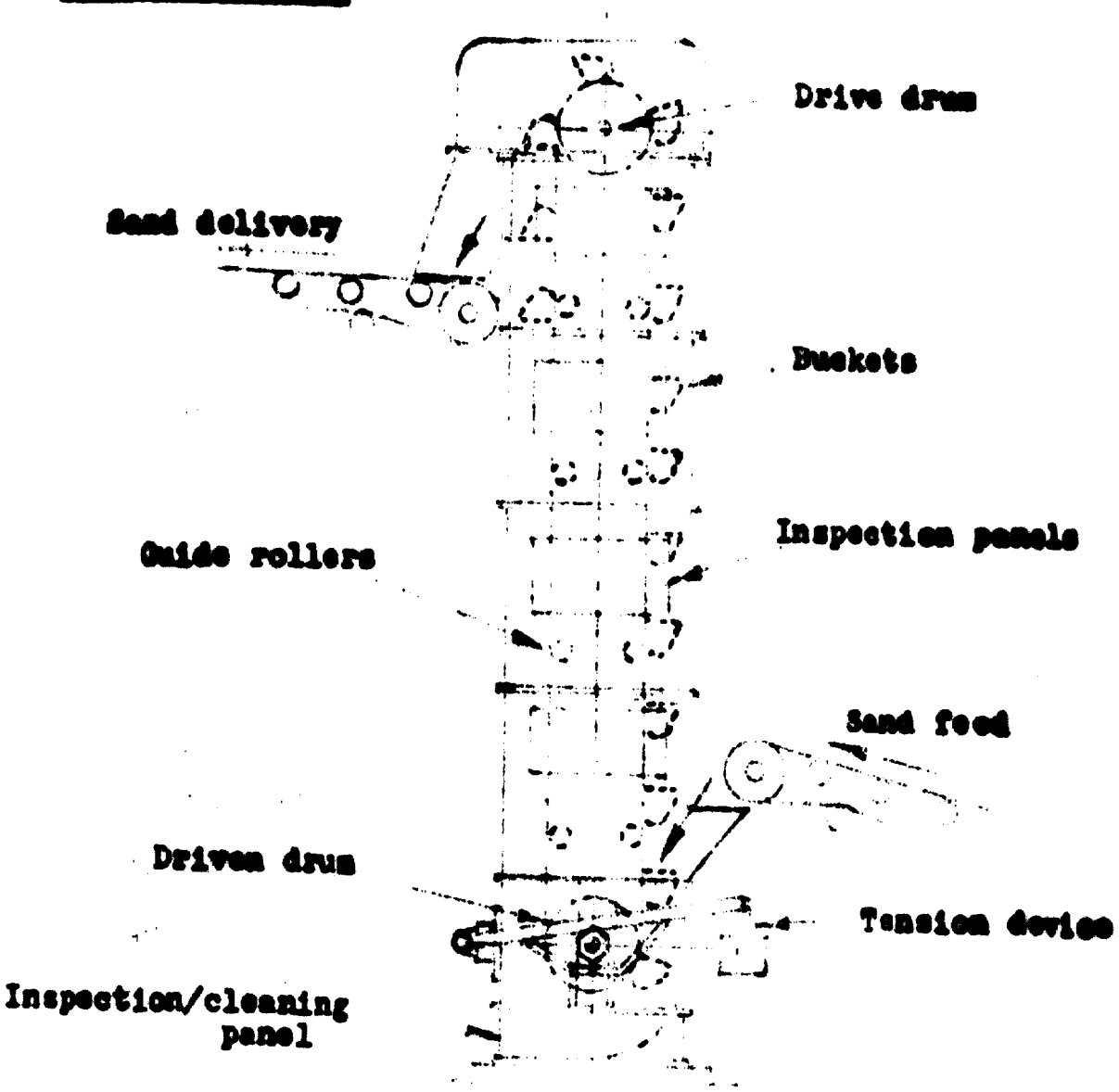
1) tracking is easier as the troughed rollers may be angled slightly as well,
2) the drive may be different, if it is a drum drive motor then it will probably require greasing only every six months and then only a little. After 1-2 years the whole unit will require new grease throughout and a thorough inspection. Also regular checks for current reading, temperature, etc. should be made as before.

General Notes

Many systems utilise crowned pulleys to assist in tracking although not on our plant. Most sand plant belts run at a belt speed of between .5 and 1.5 metres/sec., above this being rather fast and causing bearing problems, dust, spillage etc., below this requiring a different form of drive or a low geared chain drive.

There are also other types of drives for belts which must run in an indexing manner or ones which meter out quantities of sand. These are usually special adaptations and can easily be dealt with as the belts, rollers, drums, etc. all remain as before.

Bucket Elevators



These are of course somewhat similar to belt conveyors and the lubrication remains identical. The inspection required is a quick check once per week as the elevator cotton is cleaned out. This should just be to check the drum scrapers and to see that no sand is building up on the sides. Also on the daily inspection the fitter checks for unusual noises, worn bearings, belt tension, etc. Approximately every 4-6 weeks the inspection panels are removed and each individual bucket is checked for wear and the security of its fastening to the rubber belt scrutinised and finally the belt itself is checked as for conveyor belts.

Tracking is rarely a problem unless a belt is vulcanised on in a twisted manner and is done automatically on most elevators by weights transferred to the bottom (driven) drum.

The design of and around the bottom drum is extremely important if loose sand is to be prevented from interfering with the running of the belt. The drums in use on ours are crowned and are relieved in such a manner as to help gripping of the belt but also throw any loose sand out of the way.

Magnetic Separator

This is just like any of the conveyors as far as tracking and lubrication is concerned. The two differences being the D.C. supply to magnetise scrap metal onto the belt surface and the raised bars on the belt to assist in the metal removal onto a take away belt.

From experience I have found that these belts must be of first class material and that slightly cheaper ones do not prove economical. I have also found it is imperative that the raised bars be vulcanised as part of the belt and not rivetted on

afterwards. This piece of equipment creates one special problem and that is the magnetising of the surrounding steel work. This can be overcome to some extent by putting a brass plate (secured with brass nuts, bolts and brackets) between the delivery side of the belt and the return side. Aluminium or similar may be used as a cheaper substitute but it is inferior to the brass.

Double Shaft Mixer

This is a piece of equipment for breaking up all the hard lumps of sand and then dampening it to keep down the dust , also to decrease the sand mixing time. It consists in our case of two shafts each having 15 equispaced sector shaped blades which rotate in opposite directions whilst the centre distance is sufficiently small to allow the blades to intermesh, this due to the entry of sand at the top one end, the curved bottom and enclosed sides, and the exit hole on the bottom at the far end, causes sand to flow on the Archimedian principle. This equipment is driven from an electric motor through a large gearbox via vee belts.

Lubricate main bearings monthly, drive motor yearly.

Inspection daily - Motor fixing, temperature, vee belts for tightness, noise, etc; gearbox for noise, temperature, oil level; main bearings noise, temperature, feel; water flow/solenoid valve; limit switch.

Inspection nightly - Condition of the blades which should be secure and come to approx. 3mm of the outer shell.

Note: These blades have to be replaced by new or re-welded ones as soon as the hard face on them is worn through, (normally about 4-5 weeks in

the worst section i.e. middle)
(See Muller blades for re-welding).

When blades require changing it is a difficult task and takes two men a full night to replace just over half. On changing it is easiest if you start at one end and work through, taking two off, then replace one, take one off and so on.

Note: Fitted to this equipment is a revolution counter which cuts the supply of sand off if it is overloaded, i.e. if the shaft slows down. Also we have fitted a solenoid operated water valve so that when sand is flowing into the Double Shaft Mixer then an impulse is given through a flap and limit switch to allow water to flow. This has saved much production which used to be lost due to excess water in the sand. Where limit switches are used the method of actuating them should be considered so as not to put them under undue stress.

Rotary Sieve

This is one of the simplest pieces of machinery. It comprises of a many sided tapered tube made up of wooden frames filled in with wire mesh. Its purpose is to allow sand to enter at the small end and then as it rotates the sand falls through the mesh onto a belt ready for storage for further use, whilst any unwanted solids such as cores, paper, rag or metal which may have passed the magnet, will pass out of the tube again at the large end and down a chute for waste removal. Its drive is very slow by geared motor and is transmitted through a coupling.

Inspection is twice daily for rag, paper, etc. in the mesh or damage to the mesh. Also the normal motor, gearbox, and bearing inspection.

Sand Mullers

As mentioned in my introduction the two mullers accept $50m^3$ per hour of dry used sand and a small percentage of dry new sand; to this is added a percentage of coal dust and of bentonite (Fulbond). and the whole is mixed for 2½ minutes then water is added (approximately 40 litres) by spray until the automatic controller passes the sand as mouldable, it then being forced out by means of the rotating scrapers through side doors pneumatically opened. The whole cycle takes approximately 4 minutes. The mixing of the materials is by means of a bottom scraper 2mm clear of bottom, a side scraper and two continuous wheels weighing 1 ton each, suspended approximately 150 mm from the bottom of the pan. The whole rotating about a central column within the fixed pan. The mullers have a built in gearbox in the base and are driven by 150 h.p. slip ring motors with electrolytic starters, through 6 groove pulleys and vee belts.

Lubrication is mainly automatic by pumping oil up the central column to the uppermost bearings. There are however isolated grease points which are attended to two-weekly.

Inspection Daily - motor, vee belts & pulley, oil level, flow meter to show oil pumping up to bearings, water sprays, condition of the bottom scraper, side scraper, two roller scrapers, the side of the pan and the bottom of the pan.

Inspection monthly - electrolytic starters.

Inspection 3-monthly - sliprings, bushes.

At this juncture I must say that the condition of the scrapers and pan is of utmost importance if severe wear is to be prevented. For a muller to be in good condition the rollers, bottom and periphery of the pan will be seen to be polished and shining. This is achieved by never allowing

sand to adhere but to make it slide like mercury on a flat surface; to achieve this condition it is necessary to constantly check the setting and wear on the four scrapers, especially the bottom scraper. The clearance should be kept as close as is possible to the bottom with a maximum of 3 mm. Due to the face that the pan will probably be built up in many sections this may vary slightly and therefore settings must be made at the closest point.

Dependent upon your type of production there may well be another enemy to your pan condition, in our case we use 100 mm long x 1.5 mm dia. core stiffening wires which tend to bend themselves around the leading edge of the scrapers and act as cutting tools on the pan face and tending to lift the scraper. The only way of combatting this problem is to prevent it by 100% magnetic separating and to keep the setting as close to the pan surface as possible.

Maintenance - Due to the severe conditions the bottom scraper tends to require re-setting weekly and reconditioning as often as 3-4 weeks. In order to speed up the maintenance time a spare set of scrapers should be kept in readiness for immediate exchange and the worn ones immediately brought back to standard in the workshop.

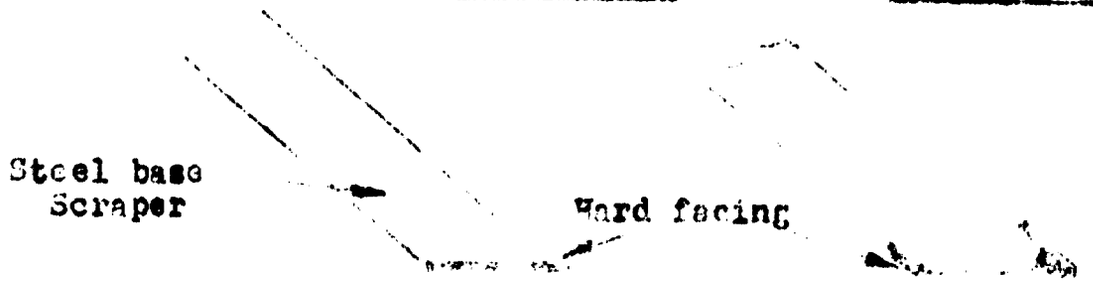
The side and roller scrapers will only need re-setting every 4-6 weeks and may only require re-conditioning at 6-monthly intervals.

Note! This is in a reasonably well kept muller.)

With regard to the type of scraper blades in use and their maintenance please use this paragraph to cover sand mullers, double shaft mixer and sand aerator (disintegrater)

All the blades mentioned are of a mild steel base metal with a hard facing to take the main wear.

Original Muller Bottom Scraper Redesigned Scraper



This basic principle of hard facing is widely used on this type of equipment and therefore various companies have developed their own product, some are applied by oxyacetylene in rod form, whilst others are applied by electric arc and others may be sprayed on.

This is a rather costly part of our maintenance and therefore, I like others, have experimented to try and improve blade efficiency and also to reduce production costs. Up to the present time I have tried five different hard facing materials and am about to try changing the form of the blade to reduce the necessary hardened area.

The results of my work will not be true in all cases as some companies have better facilities for special welding, they may be able to purchase certain materials at a cheaper rate and also the muller condition, type of sand, design of muller, will vary. Nevertheless my experience is that so far I have been unable to obtain a more durable material than one obtained from Germany but due to the high cost, (which is magnified due to purchasing from Germany), I have also in use a set of blades made locally, these being blades coated with a sprayed steel alloy. These last approximately 75% as long as the others, but are on the other hand some 25% cheaper including the actual re-conditioning.

I am at the moment considering an experiment using Linatex

which is as some of you may know a special rubber used for lining equipment which has to contain flowing sand. Various companies are using this in their sand mullers successfully but the design of our specific blade in its present form does not lend itself to this material.

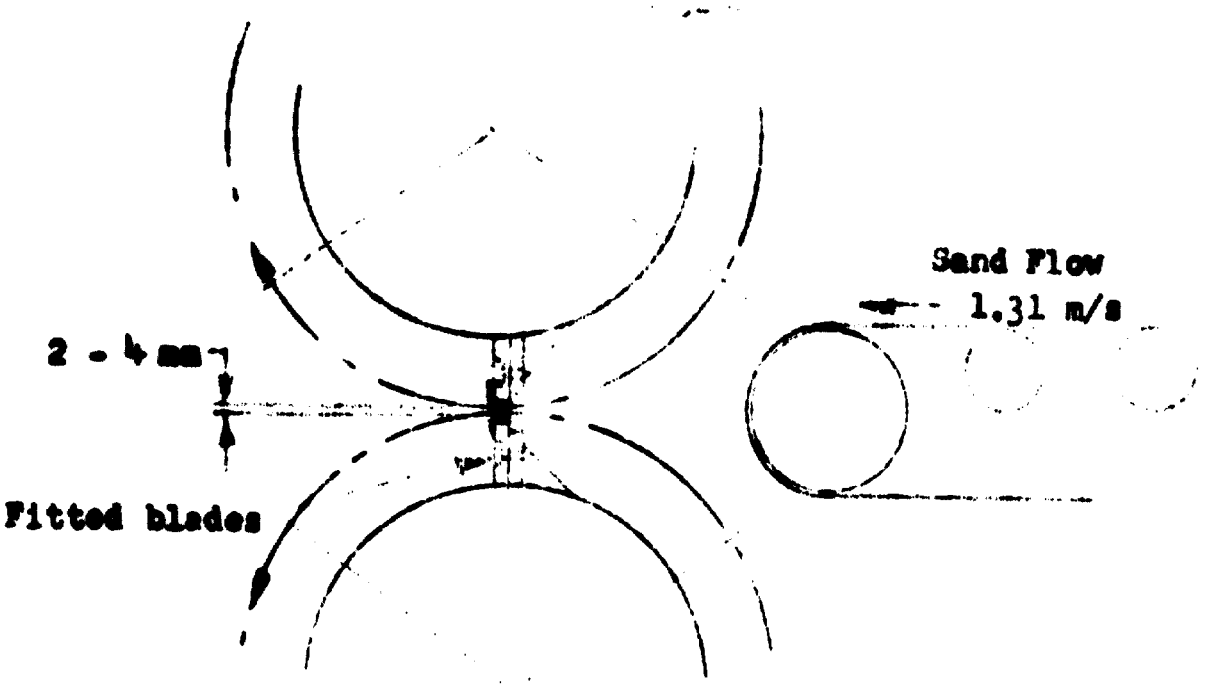
Two final comments on this subject:)

1. when the pan does begin to wear give it your utmost attention and order new liners at once. It is a fact that within 3 months a whole sand muller can be scrapped if not run properly.

2. whenever your mullers have to stand more than 12 hours out of use, wipe or spray the inside of the pan with a very thin oil or similar to prevent oxidation.

Sand Aerator or Disintegrator

This piece of equipment is found in one form or another in all foundry plants and usually takes the form of a conveyor belt which feeds sand under, over or between rotating wheels, which fling the sand to take out any lumps and to supply a homogeneous, lightly textured sand for moulding. Our particular aerator is designed to pass $70m^3$ of sand per hour maximum and is in the form of a short flat belt which feeds sand between two 6-bladed drums, rotating in opposite directions, in order to throw the sand forward up the main conveyor. These blades are fixed as shown, and only require hard facing on the relatively small area which actually flings the sand (this is soon apparent by watching the wear pattern). When fitting new or re-conditioned blades it is extremely important to check that the two drums are correctly balanced or dangerous vibrations may be set up.



Each drum and the conveyor belts having seperate drives, the drives being via pulleys and vee belts direct from 20 h.p. electric motors and the conveyor drive being similar except for the addition of a gearbox.

Inspection daily - as for previous conveyor belts; motors, bearings pulleys, vee belts, gearbox.

Inspection weekly- condition of rubber wearing strips which prevent abrasion of the metal structure. Condition of the throwing blades.

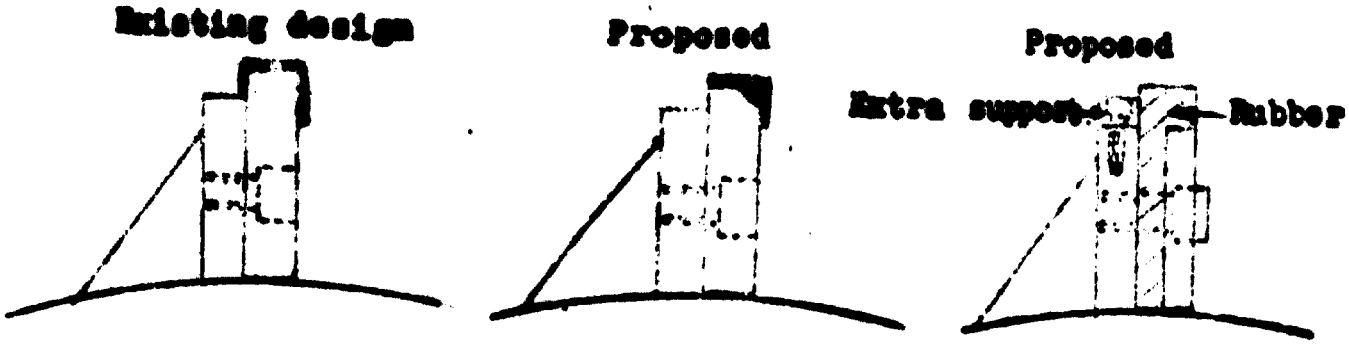
Lubrication - as with conveyors; check main drum bearings, these require special attention as in our case they tend to run hot. If too much grease is used the grease will melt and become useless or if insufficient the bearings will collapse or seize. These are usually given a little grease every two weeks.

Maintenance - the only special maintenance is that needed on the throwing blades. These need re-conditioning about every 4-6 weeks and the job is approached as on the mullers. The time factor varies for exchanging blades dependent upon the condition of the head of the socket head cap screws

holding the blades in position, but usually takes about 4 hours for two men to do one set i.e. one drum. It is to be noted that any nut or bolt used under these conditions will become severely worn and need replacing each time, also that it is a bad mistake to ever leave any threaded portion unprotected.

It may be of interest that experiments done on these blades have been most rewarding probably due to the less abrasive condition to that of the muller. In this case the cheaper blades are more economical as the wear appears only slightly worse than using German hard facing. Another important factor is that using the German hard facing method, the blades tend to warp and become difficult to refit, also the desired clearances are difficult to attain.

At the moment I am again experimenting on these blades after studying the wear patterns and the following will probably be my next two developments.



Note! On this type of equipment do not overlook the necessity of fairly accurate balancing.

OBJECTIVE 3

If we are to improve the efficiency of our plant and of our department we must realise our full responsibility to be always striving for it. I think that it is true to say that most engineers do have this kind of outlook to some degree and so it is my aim to help you to re-focus your minds on certain aspects along these lines.

The first thing that I think about is:-

"How can I improve my department?"

To answer this question you must study how the department functions item by item and continually ask yourself questions such as:-

Am I duplicating work?

Am I delegating so as not to waste my time?

Am I getting information across?

Am I receiving correct information back?

How many times is the system falling down and why?

The answers to these questions can only be found in your own situation and if this approach is taken it is certain that you will find some way of improving.

If you feel that your system is good but is still not working properly either you must modify it or you may simply be short of personnel; find out where and if it is economical, increase your staff.

In a larger company with complex stores and planned maintenance schemes, it is very easy to build up an excessive administrative staff, in these circumstances your thoughts should centre around - good filing systems, sorting machines, preprinted sheets, well organised stores, anything to cut out unnecessary work or to simplify work that has to be done.

For the very large concerns, does your set-up warrant

OBJECTIVE 3 (contd.)

computerisation? automatic storing and withdrawal? numerical control?

"How can I improve plant utilisation?"

By cutting down on breakdowns and by speeding up breakdown repair time.

"How can I cut down on breakdowns?"

a) Inspection, training, studying, analysing and acting upon records. Insufficient emphasis is placed upon these in many cases but swift improvements can be made by giving more thought to them.

b) Consider new techniques for fault finding, locate them before they become serious.

e.g. Noise and vibration analysis,
Non-destructive testing,
X-ray techniques,
Ultrasonics.

c) When work is carried out, try to improve on the previous design, i.e. " design out " vulnerable parts.

d) All parts grow older as we do - replace them before inefficiency occurs when economical. Remember that it may be more costly to repair and continually maintain than to supply a new part. Also check whether the part is outdated, study the market for an improved design.

e) Deploy your labour correctly by covering inspection, repairs during production where possible, preparation for and carrying out of preventive maintenance.

"How can I speed up repair time?"

a) By being forewarned by utilising a good inspection system.

b) By ensuring that your staff know the plant well and that they know where to locate information, spares and equipment.

OBJECTIVE 3 (contd.)

c) By checking when possible yourself if the repair requires your personal attention.

d) By standardising on equipment, not only by using interchangeable units but by keeping to the same methods of fixing, bolt sizes, etc.

e) By providing easily removable guards, accessible lifting points, electrical power sockets, good lighting, etc.

f) By selecting and training staff who, with or without supervision, can decide when and when not to carry out emergency repair techniques.

g) By knowing about all kinds of emergency repair techniques and training your staff to use them.

1) The best known emergency repair is the electric arc welding set and this should not be frowned upon when used correctly and in the proper circumstance.

2) Another much discussed but little used technique is that of building up shafts, filling in holes, strengthening structures etc. by using one of the many epoxy resins. There are many on the market which are suitable for most purposes. In some cases, a more durable finished product can be achieved than the original. The base material can be changed to contain aluminium, slate, fibreglass and so on to suit a multiplicity of applications. These materials are easily applied, dry quickly and are generally easy to machine or work by hand.

3) In some cases when a very hard or accurately finished product is required e.g. a shaft or roller, the answer may be to use a spray welding technique. Here again, there is now a very large range of materials and

OBJECTIVE 3 (contd.)

equipment on the market. The application is surprisingly easy but the decision of when to use it can be critical due to the effects of heat, therefore it is worth having your staff professionally trained in its use.

4) Always allow your trained staff to use their own initiative, it is a fact that people work more efficiently when they feel a purpose to their job, when they do not have to behave like robots and when they can feel a pride and an achievement in what they are doing.

Remember that you cannot cover every aspect for 24 hours per day and if you try to, your plant will become inefficient due to your own inefficiency. Delegate, trust your staff and let them get on with their job. Many of these men will have many years of practical experience and you may be glad to learn one or two emergency repair techniques from them.

Conclusion

In conclusion may I say that it has been impossible to give more than a glimpse of foundry or general engineering and that there are many items of equipment about which I have said nothing such as water pumps, automatic lubrication, meters, gauges, coolers, hoists, etc. However I hope that I have achieved my three objectives and that some of our minds may have been revitalised. I also hope that my paper has been both of interest and assistance to some of you and has helped to focus your minds upon the various aspects of our work which can make us effective instruments in a fast developing, efficiency and cost conscious industry.

BASIC NIGHTLY LUBRICATION ROTA AND OTHER DUTIES

Items to be lubricated	Lubricant	Nightly (1 week)
4 box carriers (including locators) Cope & Drag	Shell Alvanea RA	
Turn over units(4 places) Cope & Drag	" " "	
Metal bogies	" " "	
Lump breakers x 2 off	" " "	
3 box carriers - Cope & Drag . ..	" " "	
1 box carrier - Cope & Drag . ..	" " "	
Jolter oil bottles, ¾ full	Tellus 29	
All other oil bottles, ¾ full ..	Tellus 15-Summer Walkers Non Freeze -Winter	
Other Duties		
Clean sand hoppers out and sand filling boxes including probes	.....	
Brush down behind moulding machines....	.....	
Clean sand from around 4 lifting cylinders.....	.....	
Clean squeeze heads.....	.....	
Clean out maintenance workshop.....	.....	
Clean out rest room	.....	
Clean under brush unit.....	.....	
Clean under turnover units.....	.....	
Assist Maintenance team when requested		
Check all gearbox oil levels -		
Muller I	Vitrea 41	
Muller II	Vitrea 41	
Double Shaft Mixer	Vitrea 41	
Main pallet conveyor drive	Marcoma 75	
Apron conveyor drive	Marcoma 275	
Top up as required and report if excessive		

Signature_____

BASIC WEEKLY LUBRICATION ROTA

Item to be lubricated			Lubricant			Work Complete
Elevator 47)			Shell Alvania RA			
" 65)	Main bearings, only		"	"	"	
" 110)	top and bottom drums		"	"	"	
" 112a)			"	"	"	
Conveyors 112		)	"	"	"	
111		)	"	"	"	
109		)	"	"	"	
74		)	"	"	"	
35	x 2 off	)	"	"	"	
36		)	"	"	"	
37		)	"	"	"	
38		)	"	"	"	
39		)	"	"	"	
45		)	"	"	"	
39a		)	"	"	"	
48		)	"	"	"	
50		) Main	"	"	"	
54		) drum	"	"	"	
56	x 2 off	) bearings	"	"	"	
58	x 2 off	) only	"	"	"	
59		)	"	"	"	
61		)	"	"	"	
63		)	"	"	"	
107	x 4 off	)	"	"	"	
68	I	)	"	"	"	
68	II	)	"	"	"	
70		)	"	"	"	
71		)	"	"	"	
72		)	"	"	"	
2	x 4 off	)	"	"	"	
Pneumatic Cylinders on 54		)	"	"	"	
61		) A	"	"	"	
72		) little	"	"	"	
74		) only	"	"	"	
Wire ropes on Acrow hoists			Demag graphite			
Other jobs:-						
Clean out hydraulic driptrays						
Clean down hydraulic valves						
Clean out hydraulic pump room						
Clean stores						
Check oils, greases and equipment						

Signature_____ _____

BASIC FORTNIGHTLY LUBRICATION ROTA

Item to be lubricated		Lubricant			Work Complete
Elevators 47) All belt guide rollers		Shell	Alvanea	RA	
" 60) and lateral guide rollers		"	"	"	
" 110) (only a small amount of		"	"	"	
" 112a) grease to be used)		"	"	"	
Conveyors 112	)	"	"	"	
111	)	"	"	"	
109	)	"	"	"	
74	)	"	"	"	
35 x 2 off	)	"	"	"	
36	)	"	"	"	
37	)	"	"	"	
38	)	"	"	"	
39	)	"	"	"	
45	)	"	"	"	
39a	)	"	"	"	
40 (Magnet belt)	)	"	"	"	
48	) All	"	"	"	
50	) bearings -	"	"	"	
54	) only a	"	"	"	
56 x 2 off	) small	"	"	"	
58 x 2 off	) quantity	"	"	"	
59	)	"	"	"	
61	)	"	"	"	
63	)	"	"	"	
107 x 4 off	)	"	"	"	
68 I	)	"	"	"	
66 (Scissors)	)	"	"	"	
68 II	)	"	"	"	
70 (Aerator)	)	"	"	"	
71	)	"	"	"	
72	)	"	"	"	
2 x 4 off	)	"	"	"	
48 II (new magnet belt)	)	"	"	"	
Mullers 64 I		"	"	"	
64 II		"	"	"	
Polygonal Sieve 51 (very small quan.)		"	"	"	
Double Shaft Mixer 49 (" " ")		"	"	"	
Apron conveyor (113) rollers and end bearings		"	"	"	
Punch out, rollers, lifting pivots		"	"	"	
Main pallet conveyor (16) crank bearing		"	"	"	
" " " clamping mechanism		"	"	"	
" " " guide rollers		"	"	"	
Lifting station piston rod guides x 4 off		"	"	"	
Roller beam bearings x 8 off		"	"	"	
4 box carrier sprocket bearing x 2 off		"	"	"	
Pneumatic Conveying screwfeed bearings		"	"	"	
Buscon fans x 2 off		"	"	"	
Stub switches on runway system x 5 off		"	"	"	
Arrow carriage rollers		"	"	"	
Clairomats (92)		"	"	"	

BADISCHE MASCHINENFABRIK
FOUNDRY MOULDING PLANT

MAIN DRIVE TO MOULDING CONVEYOR TRACK		
Electric motor bearings and other grease lubricated parts	grease packed	Shell Alvania Grease RA
Flender reduction gearbox	oil bath	Shell Marcoma Oil 75
HYDRAULIC ROOM IN CELLAR		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Hydraulic pump and system	oil filled	Shell Tellus Oil 29
SHAKING CONVEYOR		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Reduction gearbox	oil bath	Shell Marcoma Oil 275
SAND AERATOR		
Electric motor and sand thrower bearings	grease packed	Shell Alvania Grease RA
MAIN SAND MILLS		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Main mill gearbox	circulatory system	Shell Vitrea Oil 41
DOUBLE SHAFT MIXER		
Electric motor bearings	grease packed	Shell Alvania Grease RA
1st reduction gearbox (Flender)	oil bath	Shell Vitrea Oil 41
2nd reduction gearbox (BMD)	oil bath	Shell Vitrea Oil 41
MOULDING MACHINES (BADISCHE MASCHINENFABRIK)		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Hydraulic pump and system	oil filled	Shell Tellus Oil 29
Pneumatic lines	oil mist lub.	Shell Tellus Oil 15
Other grease lubricated points	grease nipples	Shell Alvania Grease RA
AUTOMATIC TURNTABLE MOULDING MACHINES (BADISCHE MASCHINENFABRIK)		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Hydraulic pump and system	oil filled	Shell Tellus Oil 29
Spur and bevel gears, rack and pinions	oil fed	Shell Talpa Oil 30
Pneumatic lines	oil mist lub.	Shell Tellus Oil 15
Other grease lubricated points	grease nipples	Shell Alvania Grease RA
SAND SLINGERS (BADISCHE MASCHINENFABRIK)		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Hydraulic pump and system	oil filled	Shell Tellus Oil 29
Other grease lubricated points	grease nipples	Shell Alvania Grease RA
Sand Conditioning Plant and Moulding Plants - conveyors, elevators, skip hoists, shakers and vibrators etc.		
Electric motor bearings	grease packed	Shell Alvania Grease RA
Or/geared motor bearings, gearbox	grease packed	Shell Alvania Grease RA Shell Simnia Grease O
Other grease lubricated points	grease nipples	Shell Alvania Grease RA
Hydraulic pumps and systems (where applicable)	oil filled	Shell Tellus Oil 29
General		
Oil filled electric switchgear and transformers		Shell Diala Oil B
Heavy duty gearboxes		Shell Marcoma Oil 75
Metal Feeding		
Ladle gearbox		Vitrea 75
Receiver gearbox		Vitrea 79
Hoist block reduction box		Marcoma 75
Travel block reduction box		Simnia III
Receiver motor Hoist block motors		Alvania RA

Under Geared Motors
Gearbox
Motor

Grease Simnia O
Grease Alvania RA

Drum Motors (Bauer & Himmelwerke)
Gearbox

Grease Simnia O

FIG. 2

TO BE HANDED IN WEEKLY

The following jobs are to be carried out by the stated personnel

	Tick when complete M	T	W	T	F
DURING EACH SHIFT - To be done by fitter technician helping operator.					
Check down gate cups					
Check patterns					
Grease carrier & clean					
Clean machines down, check punch out.					
Great Turnover					
DURING EACH SHIFT - To be done by other fitter technicians on shift					
Top-up oil lubricators on cope and Drag machines (only ¾ full)					
Drain 5 off air taps.					
Check water flow to and sludge from Clairomats					
Check water flow in tank and pumps					
Visual inspection of all belts and skirts					
Visual inspection of all 'V' belts (mullers, clairomats, double shaft mixer, aerator, apron conveyor, Duscon extraction units)					
Grease metal ladles.					
Visual inspection of all hoppers. pumps and reservoirs. hydraulic units. punch-out, clamp and declamp, mechanical and pneumatic. cope machine mechanical and pneumatic. drag machine mechanical and pneumatic. ladles and hoists.					
Visual inspection of air equipment, blades and water jets on sand mullers.					

Top-up lubricators on air to mullers, pneumatic conveying sand plant plough air supplies (only ¾ full)

Check oil flow on mullers

Check elevators for sand build up.
Check fuel oil in tank.

* Please check daily the quantity of fuel oil in the tank for the hot metal receiver and notify P. Cordiner. If P. Cordiner is ever unobtainable notify E. Trueman.

N.B. Please inform P. Cordiner of oil quantities used when topping up and grease used in grease pump.

MAINTENANCE SHIFT - to carry out all planned inspections, planned jobs and unplanned jobs.

Any work not carried out to be done the following day when possible or where necessary passed on to the following shift.

This is the responsibility of the fitter technician who is unable to carry out the work.

PC/EF
26.11.68

FIG. 2a

SUGGESTED ROUTE FOR TOTAL PLANT VISUAL INSPECTION

Enter cellar at drag end, pump room, up to drive of apron conveyor, back round whole cellar, leaving by same staircase as entry. Empty drag and hydraulic sub-station.

Brush Off.

Back of drag machine.

Full box drag and hydraulic sub-station.

Main Drive

Full box cope and hydraulic sub-station.

Clamping, Ladles, Hoists, Stub Switches and Runway, then over track to back of cope machine.

Punch-out and de-clamping under pallet track at rear of punch-out, round to front of punch-out and hydraulic sub-station.

Empty cope and hydraulic sub-station.

Over steps to inside of cope and drag machines and pattern transfer equipment up to first floor sand plant tour.

3rd floor - tour clockwise, i.e. mullers first

4th floor - " "

5th floor - " " i.e. elevator, double shaft mixer, feeds to mullers, conveyor, mixed sand elevator.

Down to 4th floor, down vertical ladder, conveyor 112 out to sand feed and pneumatic conveying.

Back to aerator and sand feed to moulding machines down to ground floor. Check conveyors at rear of Sand Plant. Check Clairomats.

Collect key from Engineers and inspect water pump.

NOTE!!

All visual checks can be done during this inspection also, air lines can be checked as drained and lubricators topped up.

MOULDING MACHINE INSPECTION

INSPECTION OF DRAG MACHINE

Hydraulic Sub Station

Check: for leaking valves and connections.

Lifting Cylinders (See list of inspection for all Hydraulic Cylinders)

Check: Guideways and rods.

Roller Beams

Check: Hydraulic cylinders, box rollers, state of all bearings.

Single Box Carrier

Check: Hydraulic cylinders, cams and cam followers, state of location pins, mechanism for correct operation and condition.

Rotating Brush

4 Box Carrier

Check: Dowel pins, carrier pins, hydraulic cylinder, pin actuater, carrier retainers (sprung blocks), coupling bolts on Kracht motor, oil connections and bolts on Kracht motor.

3 Box Carrier

Check: Hydraulic Cylinders, cams and cam followers, state of location pins, mechanism for correct operation and condition.

Turnover

Check: Actuator operation fixing, end connections, cams, cam followers, general mechanism for operation and wear, keys on shaft, hydraulic cylinders.

Roller Beams

Check: Hydraulic cylinders, box rollers, state of all bearings.

Lowering Cylinders

Check: Guideways and rods.

Centralising Cylinders

Check: Guideways, rods and pins.

Hydraulic Sub Unit

Check: for leaking valves and connections.

Box Through Feed Rollers

Check: Free rollers and braking rollers for correct operation and wear, braking cylinders for wear and leaks.

Moulding Presses

Check: Proximity switch positioning bar for secure fixing, grease pump for grease usage and operation, vibrators, all rubber hoses, patterns, condition of squeezing heads, squeeze head slide wear, squeese head hydraulic cylinder, cams and followers, sand hopper (down), sand hopper clean (inc. level probe), sand hopper flaps for operation and wear, rollers and guides, sand flap hydraulic cylinder, sand frame springs and guides, sand take-off belt for tension, tracking, scraper position and general condition.

Check: Rollers and rollers, hydraulic cylinders, carriage rollers and chain drive.

All Oil Bottles to be three-quarters full

All Air Lines to be drained, gauges operable, valves operable

All Air Filters to be checked

INSPECTION OF COPE MACHINE

Hydraulic Sub Station

Check: for leaking valves and connections.

Lifting Cylinders (See List of Inspection for all Hydraulic Cylinders)

Check: Guideways and rods.

Roller Beams

Check: Hydraulic Cylinders, box rollers, state of all bearings.

Single Box Carrier

Check: Hydraulic Cylinders, cams and cam followers, state of location pins, mechanism for correct operation and condition.

Rotating Brush

4 Box Carrier

Check: Dowel pins, carrier pins, hydraulic cylinder, pin actuator, carrier retainers (sprung blocks), coupling bolts on Kracht motor, oil connections and bolts on Kracht motor.

3 Box Carrier

Check: Hydraulic cylinders, cams and cam followers, state of location pins, mechanism for correct operation and condition, condition of blow-off arrangement.

Turnover

Check: Actuator operation fixing, end connections, cams, cam followers, general mechanism for operation and wear, keys on shaft, hydraulic cylinders, gauge operable.

Roller Beams

Check: Hydraulic Cylinders, box rollers, state of all bearings.

Lowering Cylinders

Check: Guideways and rods.

Centralising Cylinders

Check: Guideways, rods and pins

Hydraulic Sub Unit

Check: for leaking valves and connections.

Box Through Feed Rollers

Check: Free rollers and braking rollers for correct operation and wear, braking cylinders for wear and leaks.

Moulding Presses

Check: Proximity switch positioning bar for secure fixing, grease pump for grease usage and operation, vibrators, all rubber hoses, patterns, down gates, condition of squeezing heads, squeeze head slide wear, squeeze head hydraulic cylinder, cams and followers, sand hopper (down), sand hopper clean (inc. level probe), sand hopper flaps for operation and wear, rollers and guides, sand flap hydraulic cylinder, sand frame springs and guides, sand take-off belt for tension, tracking scraper position and general condition.

All Oil Bottles to be three-quarters full

All Air Lines to be drained, gauges operable, valves operable.

All Air Filters to be checked.

BRUSHING DEVICE

Check: Hydraulic cylinder, state of wire brush and its fixing bolts, rollers and guideways.

PALLET CONVEYOR DRIVE

Check: Motor fixing, brake and clutch operation, coupling, gear box for oil level, leaks, noise, movement, bearings in crankshaft, clamp fixing and wear, hydraulic cylinder, bearings, rollers and cross head slide wear.

PUNCH OUT

Check: Lifting cylinders, chain/sprocket condition, slideways, punch out cylinders, punch out blocks for condition and fixing, hydraulic traverse cylinder, lifting frame percussion bars, track scraper condition and fixing, vibratory motors (4 off), fixing bolts, vibrator chute condition, drive coupling, motor fixing.

Punch Out Hydraulic Sub Unit

Check: for leaking valves and connections.

Box Clamping

Check: Clamping cylinder, wire rope condition and fixture, hydraulic lifting cylinders, adjustable lifting blocks and bearing condition.

Box De-clamping

Check: Lifting cylinders and lifting block adjustment.

FOR ALL HYDRAULIC CYLINDERS, CHECK THE FOLLOWING:

Security of Fixing.

Leakage at Connections.

Leakage through Seals

Connecting Rod Fastening.

Condition of Connecting Rod.

Correct Operation.

FIG. 4a

MAINTENANCE SCHEDULES

B.M.D. Ref		Location		Pos. No.	
Plant No	**Equipment Description**	**Task No.**	**Job Description**	**Period**	**Estimated Time**

FIG. 4b

WORK TO BE CARRIED OUT EACH NIGHT BY THE 9 - 7 SHIFT

M	T	W	T	F

Inspect that sand hoppers are emptied and cleared.

Grease 4-box carriers and turn overs

Drain all air lines

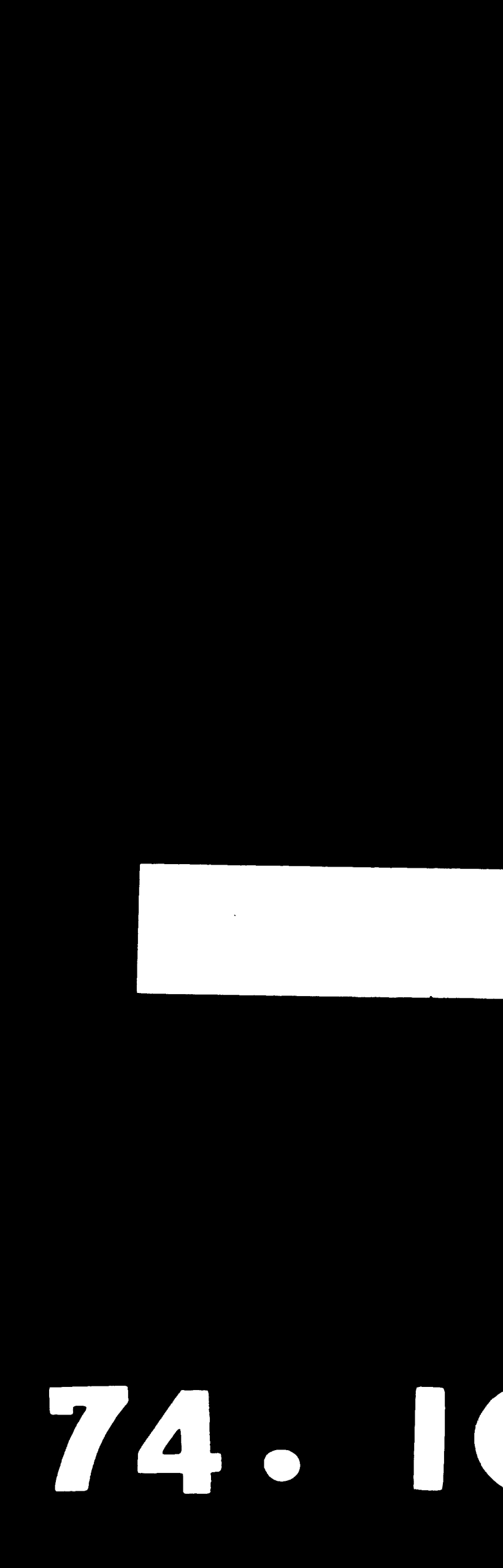
Check all Demag hoists for :-

- Wire permanent kink
- Wire wear
- Wire broken strands (allowable 5 strands in 30 mm.)
- General Condition
- Safety

Check all ladles, gearboxes and harnesses

Warm plant up - 5.30 a.m. Summer
5.15 a.m. Winter

Put sand in 5.45 a.m. to be ready before 6 a.m., i.e. boxes on pouring section.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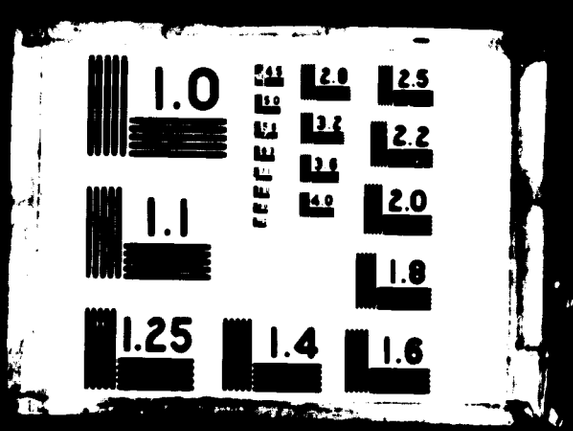

DAILY JOBS
(M/C SHUTDOWN)

	M	Tu	W	Th	F	Remarks
Inspection of Hoists Limit Switches						
Cables						
Busbars						
Test Operation of Brakes						
Inspection of Proximity Switches on						
Core M/c.						
Drag M/c.						
Punch Out						
Brush						
Clamping						
De-clamping						
Inspect Cables to Level Controls on Moulding M/c.						
Plus M/c. shutdown jobs on weekly/monthly/6 monthly inspection						
Also any repair found or daily running inspection.						

FIG. 40

DAILY JOBS
(M/C RUNNING)

	M	Tu	W	Th	F	Remarks
Inspection of Motor area on -						
Old Sand						
New Sand						
Prepared Sand						
Mixed Sand						
Mixers						
Clairomats						
Pneumatics						
Water Pumps						
Hydraulics						
Mould Conv.						
Castings Conv.						
Vibration Conv.						
Box Vibrators P/O						
Inspection of Limit Switches and Solenoids on -						
Old Sand						
New Sand						
Prepared Sand						
Mixers						
Pneumatics						
Inspection of Pressure Switches on -						
Hydraulics L.P.						
Hydraulics H.P.						
Inspection of Solenoids on -						
Hydraulic Pumps						
Drag M/c. (3 Units)						
Cope M/c. (3 Units)						
Punch Out						
Inspection of Pattern Transfer Bogie and King Hoist						
Inspection of Moulding M/c. Control Panel & Push Button Stations - Inspect contacts and replace lamps.						
Inspection of Sand Plant Control Panel & Desk - Inspect contacts & replace lamps.						
Inspection of Lighting - replace lamps.						
Inspection of Water Meters on Mixers.						

ETC. 1e

MAINTENANCE TO BE CARRIED OUT ON THE DEMAG HOISTS

M E C H A N I C A L

Description	Frequency
Test operation of limit switch	Weekly
Clean & oil limit switch operating rod	"
Check rope and rope guide	"
Check rope end securing device	"
Grease rope, drum, and rope guide	"
Check path of rotor displacement; adjust as required	"
Check oil level	"
Change oil - 2 pts. approx. of (Marcoma 75)	Monthly
Check tightness of all nuts & bolts	"
Check buffers on monorail tracks and crab runways	"
Check load hooks for crack and cold deformation	Yearly
Inspect monorail carriages and crab travel gears	Monthly
Change grease in travel hoist gears(Simnia O)	Yearly
Lubricate ball and roller bearings of motor and rope drum and the coupling	Yearly

E L E C T R I C A L

Check collectors	Weekly
Check electrical installation and control equipment	Yearly
Inspect motors	Weekly

RECORD CARD

REG. NO. BMD	LOCATION	POSITION NO

DATE	PLANT NO	REPAIRS	INSPECTIONS	MODIFICATIONS	MP	COST M	COST TOTAL

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M+I

INVENTORY CARD

POSITION NO.

CMD. REF. NO.

HEIGHT	LENGTH	WIDTH	WEIGHT
DESCRIPTION		LOCATION	
COST		ORDER NO.	
DATE INSTALLED		DATE COMMISSIONED	

MOTORS PLANT NO.	MAKER	SERIAL NO.	H.P.	R.P.M.	VOLTS	AMPS	PHASE	TYPE
REDUCTION BOX NO.	MAKER							

OTHER ITEMS PLT. NO.		
CARTER PLANT NO.	MAKE	TYPE & VOLTAGE
OTHER ELECTRICAL ITEMS PLANT NO.		

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PERIOD FREQUENCY	JOB CARD	JOB REQD.
	POSITION NO:	

LOCATION	POSITION	PLANT NO.	JOB NO.	JOB DESCRIPTION	EST. TIME

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Pat. Nos. 676956, 708839, 764969 ©
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M ◆ 1

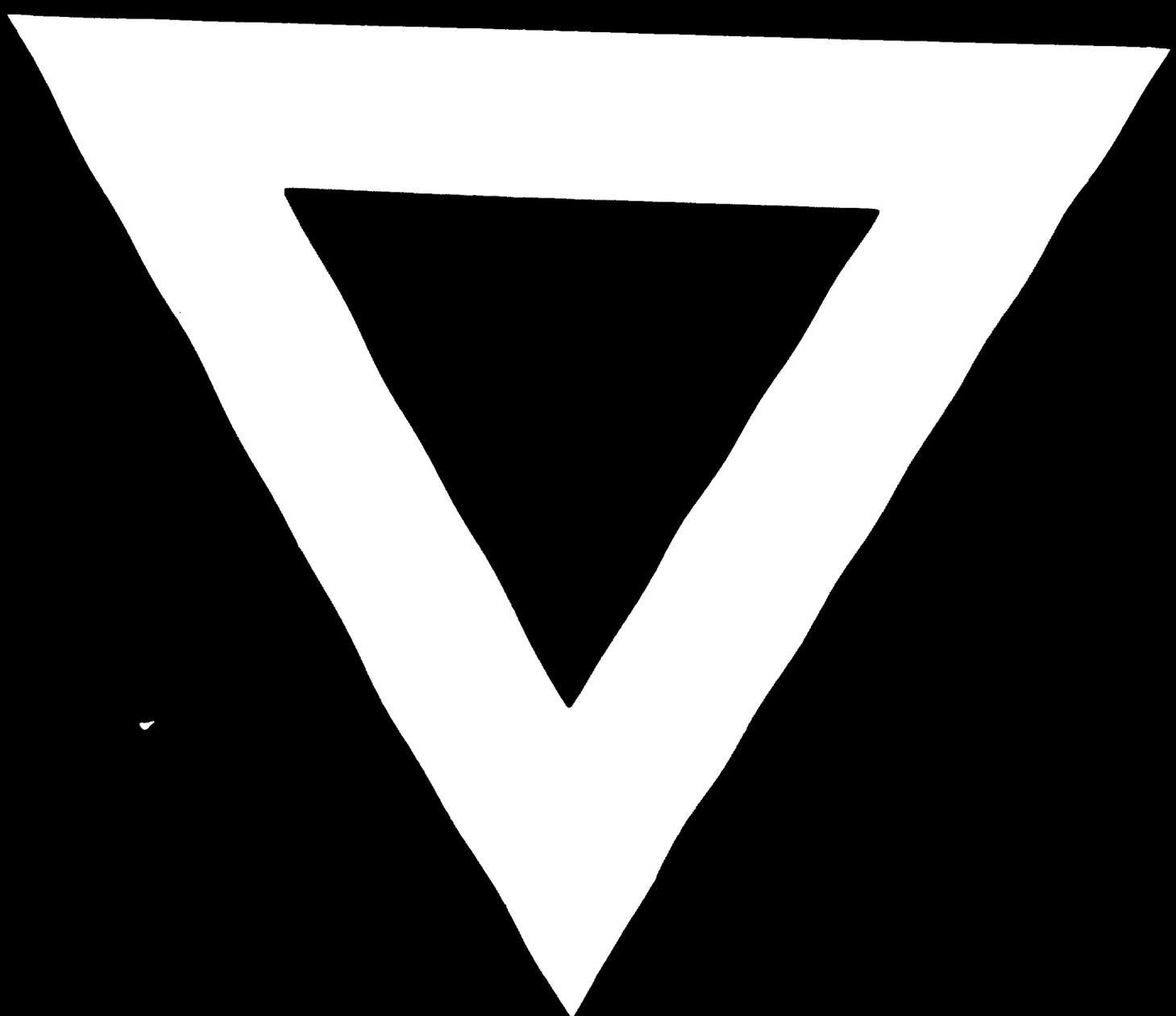
PRODUCTION DOWN TIME, DETAILS AND OVERALL PLANT UTILISATION

Waiting Metal	Waiting Cores	Waiting Labour	Mould Hardness	Pattern Change	Prodn. Down Time	Prodn. Utilisation	Overall Utilisation	REMARKS
TOTAL								
TOTAL								
DAILY TOTAL								

MTC. Sh

PLANT UTILISATION (on 7½ hour shift plus any Overtime)

Utilised Time Start	Utilised Time Stop	Reason for Stoppage (Routine or Unplanned)	Mech.	Elec.	No. Boxes	M/C Speed	Down Time	Utilisation %
1st Shift								
Shift Total					Total		Total	
Shift Total					Total		Total	



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