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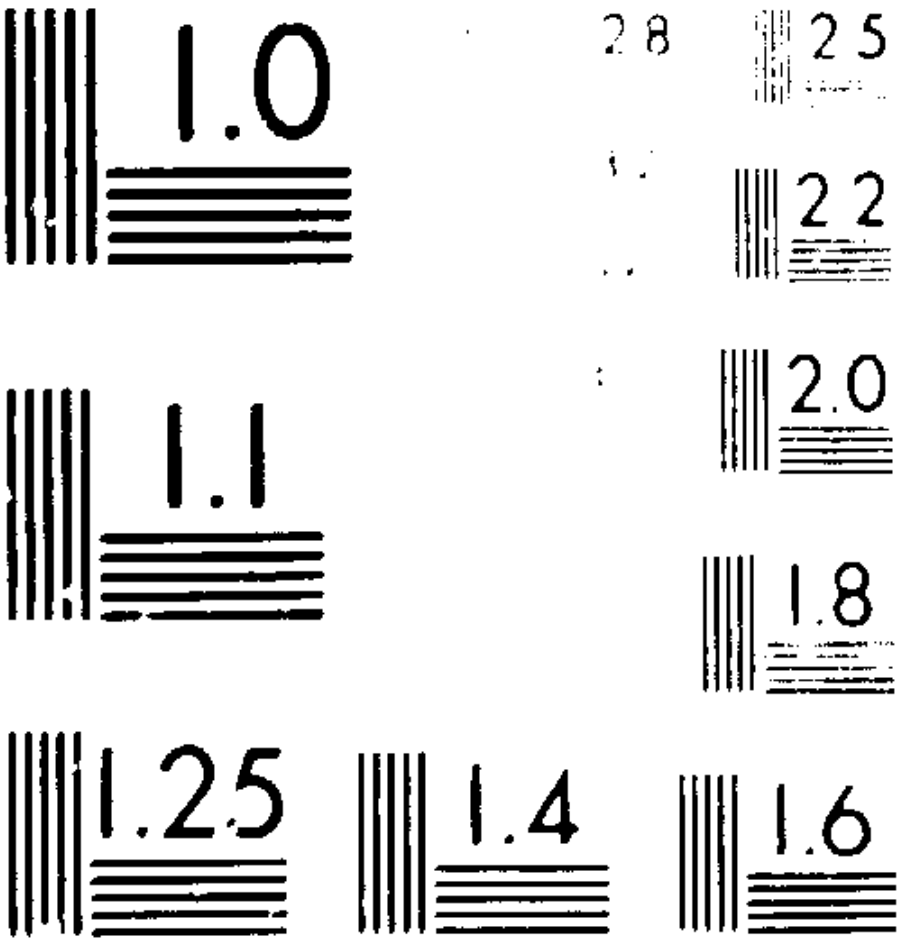
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DRILLING RIGS AND RIG UNITS FOR THE EXPLORATION OF WATER IN SPECIAL CONSIDERATION OF THE MANUFACTURING AND DEVELOPING OF RIG COMPONENTS*

VOLUME III

by

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UNIDO Consultant

* This document has been reproduced without formal editing. This report was prepared under a UNIDO subcontract. The views expressed and the material presented in this report are those of the author and do not necessarily reflect those of the UNIDO Secretariat. The three volumes on drilling rigs and rig units in special consideration of the manufacturing and developing of rig components in selected developing countries cover Volume I: Exploration of On-shore Hydro-Carbons; Volume II: Exploration of Off-shore Hydro-Carbons; and Volume III; Exploration of Ground Water.

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PREFACE

Introducing and emphasizing the importance of drilling operations in the hectic search for hydrocarbons - in two separate brochures relating to onshore and offshore operations - drilling for water, coal and other mineral deposits, shale oil, or the development of geothermal energy is definitely not less important in the long term.

In the last ten years a dramatic increasing number of water well drilling projects have been initiated and carried out especially in arid areas of Asia and Africa. With modern and more sophisticated constructions of mobile drilling rigs, the projects and development work were accomplished in a more effective way. The new rigs saved time in drilling operations and contributed successfully to the feasibility and profitability of many water well drilling projects. Large irrigation layouts are planned in some countries and are waiting for their realisation because of lack of modern drilling rigs. In some areas of the world the search for water has become priority number one and is even more important and indispensable than the exploration of oil and gas.

There is a strong similarity in design and manufacturing between many tools and equipment produced for mining and for water well drilling and others made for oil and gas drilling. Basic components are used for mineral exploration, water well drilling, for drilling blast holes in surface mining, for drilling large shafts and access holes for nuclear blasting and underground mines. We anticipate that mining of certain needed minerals for industrial production and of coal for fuel will rebound very well in the 1980's.

'Big hole' drilling is receiving renewed attention due to the development of additional applications such as for drilling vertical shafts for underground mines, for nuclear waste disposal and for access to underground shale deposits.

Overall, the long term outlook for mining world wide is very promising. Growth in mining should exceed the rate of economic expansion due to the continued use of coal as a replacement for petroleum, general economic expansion and the critical need for strategic metals for defence and industrial purposes.

Following this introduction, it is obvious that the drilling business shows one of the most dynamic growth patterns within the hydrocarbons and earth extraction industries throughout the world and has to be recognised as playing the main part in the exploration of energy resources.

Valuable conclusions can be derived from analysing the described trends and aspects in order to establish, invest and participate in this most active kind of industry.

Applicability of Water Wells

The two most popular applications of water well drilling are the production of water and the reduction of the ground water level. In both cases the water well provides the encased flow of ground water, as opposed to the water wells which are drilled occasionally as an ooze-away well and which function to conduit surface water underground to the ground water or in some exceptional cases to ooze away waste water.

If the production of water has to be achieved, then the objective has to be, when drilling a water well, the production of the greatest possible water volume with the smallest decrease of ground water level. Considering the reduction of the ground water level on the other hand, it is the main concern, according to the total drilling depth of the well, to achieve the most possible reduction of the water level by using the least expensive means - or, in other words, with the production of the smallest possible water volume.

Water wells for the purpose of water supply are permanent installations operating continuously. Water wells for the purpose of reduction of the ground water are operating only temporarily and for a short time, often a few weeks only and rarely longer than one year.

In drilling a water well different methods have been employed to improve the economy of the operation. Rotary drilling using mud circulation, suction drilling and the air lifting drilling system are the up to date technologies used by the water well drilling industry.

INTRODUCTION

The presented technical report is one part of a comprehensive study on drilling rigs for offshore and onshore exploration work. The original study has been split up in three parts in order to correspond to the requirements of actual conditions which are different from country to country. On top of that it makes it easier to the respective reader who decided on special projects already to deal with a more handy brochure rather than with a bulky book. Nonetheless, it should be pointed out that besides this brochure, two other booklets have been published at the same time which cover very similar equipment but with another application and different design.

The study discusses the different components, equipment and parts which are to be found on a drilling rig. To support this intention a rather detailed bibliography has been furnished for some of the chapters.

In some paragraphs of the report the equipment is explained part by part with regard to the eventuality of going into manufacture of these parts or components without any delay and anticipating the products which have already been given priority.

The overall objective of the report is to speed up the manufacturing and production of drilling rig components in countries where this line of industry is more or less in its very early beginnings or does not even exist as yet. The study should contribute to the intentions, planning and projects of the government concerned to increase or establish the local manufacturing of drilling rig parts within the very near future.

It is evident that certain groups of products have to be deferred from the start because of their complexity and R&D work involved. However, this does not mean that this equipment is eliminated as far as consideration for manufacturing is concerned, but that, as a time factor is involved, the less sophisticated equipment has to be focussed upon first.

Furthermore, the respective local existing facilities have to be taken into account, which represent a basic requirement for the spudding of production.

First priority should be given to the product line of drilling components in order to employ the existing national industrial capacities and human resources intensively within a booming branch of industry.

The many varied parts and equipment of a drilling rig represent a large spectrum of supply from all kinds of different branches. Unutilised capacities of plants and production facilities and unemployed, qualified or unqualified human resources can be drawn to meet the drilling industry requirements.

In some countries many companies increased their capacities remarkably in order to meet the demand of the drilling business. Many other companies were able to establish themselves as it was an absolutely new market for special products as well.

Manufacturing the components by the domestic metal working industry decreases the imports from other countries and saves the funds for other important investments needed.

Furthermore, domestic manufacturing of drilling rigs advances the exploration activities and increases the competition on a world-wide rapidly expanding market.

The study emphasises certain features, designs and material qualities which have to be met without exception in order to produce components without any defect. Some paragraphs do show basic comments and explanations of rig components which might seem to the experienced design engineer trivial or unnecessary. However, it is the intention, among other objectives of this study, to furnish readers who are not familiar with a drilling rig with the necessary basics in order to proceed more easily to the more sophisticated chapters of the brochure and other professional literature.

Besides, the content of certain paragraphs takes into consideration readers who have a mechanical, electrical, or construction engineering background, but have not been confronted with the drilling rig terminology and who know certain components on the drilling rig very well but are not experienced with their special application to the drilling operation or with the special operational features which the drilling work requires.

The study covers also modern drilling rig auxiliary equipment which is not a necessity but increases the efficiency of the drilling operation and facilitates the speeding up of the different working processes on the rig floor. Additionally, it eases the work of the rig crew.

In the course of this report the rating of each rig component is stressed out as they have to complement each other during drilling or handling pipe with regard to power and type of operation. This co-ordination of ratings is very important to the manufacturer as he has to plan the design of the respective components which have to match in order to guarantee a smooth operating of the total drilling complex.

Great care has to be bestowed on the assembly of the parts and equipment in order to pass the test and the final check up of the components for safety and reliability by the respective Association for technical inspection of the country.

The rig-up and test includes, among other checks :

1) Rig-up and test in the yard, assembling the mast, substructure, engine extension and mounting all drilling machinery thereon; running the same; setting up the pumps and connecting the drive; installing all mud manifolding, positioning mud tanks and hook-up manifolding, complete pressure testing of mud system; and complete rig test prior to disassembly for shipment preparation.

2) Furnish, assemble and install where required one lot of water, fuel, oil and air piping for the rig.

3) Furnish, assemble and install where required one lot of blowout preventer piping.

4) Dynamic brake and hoist cooling, where applicable, consists of cooling tower with three pumps.
Pumps are manifolded to tower and water tank.

5) One lot labour and material to wire and connect all AC equipment.

6) Thorough inspection of the derrick or mast, including crown block and travelling block, according to instructions established by local technical inspection authorities.

The study includes up to date tables and figures to illustrate modern rig equipment and accessories. Dimensions, ratings and layouts of components are described very accurately and references are given for further follow-up. The report is compiled from a great many up to date papers, professional literature and sources provided by the drilling industry. The author wishes to express his thanks to corporations, companies, individuals and publishers for the courtesy and permission to reproduce some of the information they have developed. Many thanks also to the University of Austin, Texas for the literature provided which has greatly aided in the research and writing.

1. Scope and Summary of the Report

The study has been initiated by UNIDO, Vienna. It should deliver a major contribution to the plans and projects of different governments to urge the manufacturing of drilling rigs and components.

Furthermore, existing local branches of industries should be encouraged to focus on the diversified products employed by a drilling rig to enlarge their capacities and facilities for this new market. Engineering bureaux, R&D departments and governmental institutions should be prepared to concentrate on the design and development of rig components and on employment of existing local facilities with regard to fabrication and manufacturing.

This report is supposed to provide the necessary information to promote and to support the engagement in this branch of industry. It should assist the institutions, project groups and advisers involved to establish and speed up the required analyses, R&D work, implementation of programs and the manufacturing by qualified suppliers.

The study is addressed to :

1.1. Ministry of Industry (Oil, Gas, Water, Minerals).

1.2. Ministry of Natural Resources (Oil, Gas, Water, Minerals).

1.3. Ministry of Finance.

1.4. Ministry of Industrial Planning.

1.5. Ministry of Energy.

1.6. Governmental Boards or Advisory Committees established for energy development projects, irrigation planning, R&D of exploration work, promotion of metal finishing enterprises, national heavy industry.

1.7. Engineering Departments of national oil and gas companies, drilling companies, prime metal working and manufacturing companies.

1.8. National metal manufacturers associations.

1.9. Engineering departments of prime compressor, pumps and engines manufacturing or assembling companies.

1.10. Electric cable and wire line producers.

1.11. Instruments, appliances and gauges manufacturing industries.

1.12. Engineering Departments of steel construction companies.

1.13. Tanks and container building or assembling enterprises.

1.14. Prime Electric motors manufacturers.

The report aims to direct the attention of all the above mentioned governmental institutions, manufacturers and producers to the manufacture of drilling rigs and components.

Furthermore, it gives suggestions to the respective authorities with regard to implementing, developing and producing the necessary equipment. Recommendations have been elaborated to advise what, how and when it should be accomplished.

In order to realise parts of this important project within a reasonable period of time the following general steps are recommended to be taken by the respective governments :

- to establish an advisory committee (technical/financial)
- to promote R&D projects
- to promote development programs
- to encourage the domestic industry providing incentives for investments.
- to obtain studies (technical and economical) from universities on technical and economical feasibility of planned projects.
- to establish professional training programs.
- to conduct surveys and employ consultants.

In order to enforce the required actions which have to be taken to achieve the overall objective, the assistance of the government through its ministries is an absolute necessity. It has to be emphasised that the support of the ministries and governmental institutions to promote development programs and R&D projects is an essential part in obtaining the desired results.

Credit also has to be given to the assistance of UNIDO which may contribute considerable experience to realize the whole project.

A team of experts - including financial, technical and technological specialists - should be available to assist the government or the appointed advisory committee to evaluate R&D projects, development programs, studies, etc. for short term or long range planning for schemes already initiated.

Furthermore, the UNIDO team should conduct a techno-economical survey throughout the country concerned under the supervision of government or appointed officials and make recommendations together with key members of the advisory committee.

The team should analyse and qualify the existing capacities, technical standards and possible capabilities of national or domestic manufacturers with regard to the eventual production of the equipment. By the same token a financial report can be established to estimate costs, funds, needed investments, etc. for the implementation of new product lines within certain domestic industries.

Finally, the UNIDO group should perform as a continuous adviser after the survey has been finished to evaluate, analyse and summarise the results of the study.

After submitting the results of the analysis to the government or the advisory committee, the UNIDO team should assist now in establishing R&D projects and development programs. During this phase of industrial planning UNIDO should be referred to as a consultant and project adviser until the first manufacturing of a prototype of a specific product line. The UNIDO experts team may be considered as in a "staff position" to the government or advisory committee during the whole time of the duration of a certain project or different projects running parallel. In case of any difficulties or obstacles of the program the team should be consulted to assist in solving the problem, provided that it is in the interest of the government.

Additionally, UNIDO can furnish the government body with consultants to meet special requirements or, if needed, to advise on a specific R&D project.

The co-ordination of different R&D projects, the management of development programs, and the supervision of pilot tests may be delegated to the UNIDO experts group or to professional representatives appointed by UNIDO.

2. Production and Manufacture of Drilling Rig Components & Units

2.1. Foreward

Anticipating certain general comments and explanations the overall objective of this study should be protected, namely to manufacture rig components. In the course of the report detailed information is furnished about certain selected components which are suggested to be focussed upon first. Nevertheless, we have to take into consideration the different levels of advancements in modern technologies from country to country. Furthermore, the implementation of certain projects may work in one area very successfully, but may not work at all somewhere in another region. The latter case should have started with a simpler or modified application of the realization of the project. Attempting to reach a common denominator, some compromises have to be admitted before commenting on the subject.

The following chapter outlines some thoughts which have to be given to certain advantages, obstacles, conditions, etc. when entering the manufacture of a new product line.

2.2. General Comments

The main concern and key question posed is what plan of action and what necessary steps have to be undertaken to go into the production of drilling rig components and parts which result in building up gradually a domestic drilling rig and equipment manufacturing industry.

Considering the drilling rig components and equipment, it can be noticed that a large and varied spectrum of parts and machinery is required to assemble the complete drilling rig. The variety of material ranges from the most simple parts to somewhat more sophisticated equipment. Steel qualities of material vary from low grade structural up to very high grade heat-treated allow steel. For someone starting out in the manufacturing of rig components, the strategy to follow is obvious :

To concentrate first on the simple and more common parts and equipment and gradually to approach the more sophisticated material.

In launching the fabrication of certain equipment, basic preparatory investigations and actions have to be organised and carried out.

The first action which has to be taken in order to carry on with special and individual development programs, considering national technological capacities, is to conduct a survey of the existing infrastructure to establish whether it can meet the demands and requirements of the intended projects. Especially, the domestic steel manufacturing companies have to be focussed upon to investigate the quality and composition of different steels which are a necessity for producing rig components.

The second investigation has to be directed in the area of the capabilities and capacities of the domestic metal working industry. This is absolutely the key to the whole project and affects all

further action, decisions and steps to be taken. It makes a big difference to economical considerations in any case if the raw steel material has to be imported or if the metal working industry is not qualified enough to meet the required standards. The latter is decidedly the most sensitive part of the project. A very important asset which has to be critically analysed is the type, number and condition of machine tools which are operated by the metal working industry. The machine tools at hand qualify the company immediately if the required capacities, capabilities and specifications can be met.

In most of the developing countries there is a lack of an organised mechanism to implement new development programs on a large scale. In addition there is a lack of appropriate provision to produce industrial engineering and supporting services such as training facilities and technical advisory services, e.g. heat-treatment techniques, sophisticated steel casting techniques, etc.

As explained in the beginning of this paragraph, a technical survey about the standard and capability of the domestic infrastructure is absolutely essential and mandatory. The survey has to be supervised by experienced technical experts with a background of mechanical engineering, metal working techniques and knowledge of steel properties and qualities. This work is recommended to be conducted with the consultants of UNIDO.

The report has to be precise and thorough. Based on the results, the government decides if the project should be realized and a plan of attack worked out, or if the project should be postponed or shelved.

Programmes based on national technological infrastructure :

- analysis of the present and existing status of standards and levels of technologies.
- advanced training programs to achieve common level of technology.
- providing instruction manuals, maintenance brochures, repair work guidelines, to establish a basic manufacturing program.
- engineering development program, with emphasis on design, material selection and respective material treatment.
- product evaluation program, mass producing, consumables, semi-finished, end product.
- co-ordination programs to combine different working processes to accomplish final product.
- operations scheduling programs, time planning to meet deadline of total project perfection.
- work program to be established to conduct operation of a prototype equipment.
- material testing and quality control.
- programs for machine tools and machinery standards and condition.
- classification of existing machinery with regard to expected technologies to manufacture new product lines.
- investment plans for heat-treatment facilities, forgeries and foundries.
- industrial development plans, such as enlarging facilities, establishing new facilities, expansion programs.
- R&D programs with regard to sophisticated drilling rig components.

The detailed and comprehensive study which is absolutely essential to estimate and to evaluate the standards and capabilities of the steel industry, metal working and engineering industry of the respective country affects the analysis remarkably with regard to which components and systems could be manufactured by domestic industry and which products have to be imported.

Another important criterion which has to be taken into consideration is the estimation of the time factor with regard to the operation of local R&D facilities and the implementation of worked out programs in manufacturing and mass production.

Incidentally, the establishment of R&D departments in several branches of the metal working industry is an absolute necessity and should be given highest priority among other industrial projects. The engineering work of this "technical cell" is very important for the rapid regional development of a domestic drilling component manufacturing industry.

It depends on the effective operation of the R&D institutions how fast the development of components and systems can proceed. Experienced engineers and draftsmen have to be employed and objectives have to be established in order to achieve a timely qualitative output. By the same token training programs have to be set up immediately in order to increase the capacity gradually and steadily.

The steel industry and the metal working industry have to immediately add special R&D set-ups to their engineering sections which have to be oriented to the development of rig components. The R&D work has to focus primarily on design, material selection and technologies involved in the manufacturing of rig equipment.

2.3. Summary of step-wise actions that may be taken by the Governments for immediate development programs.

2.3.1. Basic requirements for implementation of projects:

The Government adopts the subject into the agenda of industrial development and consults the competent ministries for a general input.

The Government decides to implement the project and asks the ministries and official institutions to initiate the first necessary planning arrangements.

2.3.2. Immediate program

The Government launches strategies, policies and directives for the production of drilling rig components.

The ministries arrange for first meetings and discussions inviting major representatives of the industry to submit proposals as to whether and how the plans and intentions of the Government can be met.

The ministries report to the Government the respective results of discussions and suggest the next steps to be taken.

The Government appoints UNIDO/UNDP to initiate a techno-economic mission to discuss with the Government the present status of capabilities and capacities of the industry and the general plans for the near future. This requires an analysis of the existing manufacturing facilities, standards of technology, available machine tools, etc., as already discussed in the beginning of the chapter.

2.3.3. The Experts Group of Unido -

advises on the R&D projects and component manufacturing promotion. The team includes :

One expert in metal working technologies. He should have a background of mechanical engineering or equivalent, approximately 10 years experience within the metal working industry, intensive knowledge of up to date machine tools, thorough experience in establishing work programs and acquainted with R&D work.

One expert in metallurgy. He should have an engineering degree, approximately 10 years experience within the steel works industry, an intensive knowledge about steel compositions and qualities, alloy steel manufacturing and finishing technologies (e.g. heat treatment, and coating processes). Some experience is required about setting up work programs.

One drilling engineer, with approximately 10 years experience within the industry. He should have worked on drilling rigs and within engineering departments experienced with specifications of drilling rig components, handling of drilling equipment and has to be familiar with the design and rating of drilling rig parts. He is supposed have an excellent knowledge of drilling techniques - and drilling operations. His experience should include supervising and manager positions within drilling operations.

One financial expert, whose qualifications should meet the ability of planning and estimating the financial requirements for technical projects, R&D programs, etc. He has to be familiar with budget plans, allocating of funds, financial resources and investment schemes. Approximately 5-10 years experience as financial controller or equivalent position within the drilling, or related industry is required. He should hold a degree from an international business school.

The team of experts should report to a technical manager who will be appointed by UNIDO to supervise the implementation of objectives, the anticipated progress and the achieved results. Furthermore, this position to be created is essential for co-ordinating and directing the important work of the group of experts in the respective country and to control the activities of the group to keep the working program on target. He is responsible for the successful accomplishment of the project and reports to UNIDO directly.

2.3.4. The Duration of the mission

This is estimated to be 3-4 months. The work program of such a mission is to be recommended as follows:-

2.3.4.1. Analysis

To review the present standard of the existing metal working, metal fabrication, metallurgical and allied industries as well as repair and maintenance workshops and determine their requirements to manufacture drilling rig components.

To analyse the number of drilling rigs operating - and the immediate demand of additional rigs. Oil and gas drilling rigs and water well drilling rigs have to be distinguished.

To evaluate the sources of steel supply with regard to quality and expected physical properties.

To analyse the proposed plans of the Government on Engineering Industrial Development and to project the trend on the need for rig components.

To consolidate the above informations and determine the possible parts, components and critical spare parts that could be manufactured locally within the next 2 years/5 years/10 years.

To review : 1) the status, condition and type of machine tools which are available within the metal working industry; 2) the present level of technologies employed and the present qualifications of manpower available.

To comment on machine tools demand, actions required to improve level of technologies and to increase qualified personnel.

To elaborate a financial report which includes required funds for the acquisition of assets, estimation of expenditures for machinery and plants, financing of training programs and R&D centres.

To locate financial resources and long term loans.

To furnish the Government with recommendations about basic investments needed to start production of certain rig components immediately.

2.3.4.2. Project Elaboration

To establish a joint industrial advisory panel with membership from the country's industries, appropriate institutions and organisations and ministries concerned, to advise and assist in program development and on future activities.

To establish, with the assistance of Government Officials, an R&D Centre or engineering cell with specialized engineering services. The engineering services to include design and development, industrial liaison, and training.

To detail a realistic two-year work program including market development, design, prototypes, production, industrial liaison and training.

To detail the physical facilities (workshop, design offices, R&D and training centre, equipment and infrastructure), technical manpower and financial requirements.

To provide list of equipment and machine tools with specifications

To provide layouts for production facilities and locations using the existing infrastructures (main consideration to be given to expansion of present facilities.)

2.3.4.3. Project Implementation

To detail the organisational structure.

To work out international assistance needed in terms of experts, equipment and fellowships/training and finances involved.

To brief the Government on inputs and finances.

To establish an implementation timetable.

To set up objectives for the successful realization of the project.

3. Rig Components to be considered for immediate Local Manufacture

The following components are suggested to be given first priority to be manufactured by the domestic or national industry to launch the production of drilling rig equipment:

3.1. The Mast.

3.2. The mast support mounted to vehicle.

3.3. Carrier base of truck for necessary machinery.

3.4. Discharge and return lines of mud circulation.

Selecting these groups of components, considerations have been directed especially to the :

- relatively uncomplicated parts
- conventional assembly techniques.
- basic maintenance and repair facilities.
- simple inventory and spare parts requirements.
- average qualification of workmanship sufficient.
- basic engineering concepts.
- common technologies employed.

The above stated components should be focussed upon immediately with regard to local infrastructure , free capacity of local machine shops and available manpower.

If the local conditions do not permit a full scale production / or manufacturing from the start, assembly and maintenance or repair of the components should be the first activities to achieve and on which to concentrate. It is important to note that the suggested components show quite a few attachments and accessories which represent kinds of bi-products such as ladders, guide rails, boards (foot, running, etc.), skid frames for additional set of machines railings, guards, pipe racks and boards.

Most of these accessories are of simple design and should not create any problem for immediate manufacturing. All these parts and attachments have to be assembled to the main components prior to the rig leaving the assembly plant. Low grade structural steel as material source is absolutely sufficient. Basic welding techniques and knowledge of common steel construction or scaffolding is necessary for fabricating and mounting of the respective accessories. The attachments and accessories are shown in different figures later on in the technical section of this report.

The following summary itemises some of the basic working processes for manufacturing the suggested rig components:

3.1. The Mast

- Design, analysis of all members in the rigid frame for stress, deflection and end moments and all related computations.
- girts, bracing members, beams, leg sections, webs - output of the rolling mill according to sizes and specifications (profile structural steel members : rectangular, round or square).
- the steel members are welded together using conventional welding techniques.
- assembly of attachments and accessories to the mast construction.
- installation of hydraulic rams.
- testing.
- commissioning.
- coating and galvanizing.

3.2. The Mast Support

- design and preparatory work.
- welding of steel members : tubular steel components or rectangular profile steel members employing conventional welding techniques.
- coating.
- bolting or pinning of mast support to base plate of carrier.

3.3. Carrier Base

- design and preparatory work.
- sheet steel and I-beams are delivered from the rolling mill according to sizes and specifications.
- steel plates are cut into the initial shapes.
- welding of steel members and bolting or pinning work to assemble.
- coating.
- mounting to carrier.

3.4. Discharge and Return Lines

- fabrication or supply of pipes 2" to 5" ID.

- fabrication or supply of connections and fittings for above (spare parts manufacturing).

- fabrication or supply of bent pipe parts for pipe layouts. (spare parts manufacturing).

- assembly of pipe layouts.

- pressure testing of pipes.

- coating.

4. Production and Repair Facilities

To illustrate size, site and fabrication facilities for a centralized production plant manufacturing the complete product line of rig components the following example shall be quoted :

The necessary different workshops may be established on a 12 to 15 acre (50000 to 60000 sq.m.) site to accommodate specific manufacturing stages of fabricating, welding, machining, assembly and finishing. A large yard space has to provide ample room for assembly and testing. A railway track leading to the premises and fabricating facilities is desirable to load and unload heavy equipment or complete units. The processing plant may have a size of approximately 40000 to 50000 sq.ft. Within this manufacturing complex the following operations are located:

forging, casting, coating, engineering, design, warehousing, stock control, quality assurance and computerised operations control (optional).
Processing : an approximate 3500 sq.ft. processing facility provides a time saving boost to fabrication and productivity. Steel plate is cut into the initial shapes in this prefabrication stage.

Welding may occupy 0.8 to 1.2 acres of the plant and may employ a work force of 40-60 welders and qualified workmanship (e.g. in high strength welding). The diverse machine shops might need 5000 to 8000 sq.ft. under roof and house well-trained machinists and NC operated machine tools. The assembly and finishing area spans approximately 7000 to 10000 sq.ft. under a roof in which teams skid mount, assemble, paint, wrap and crate all integral components. Here finishing touches are added and all parts are checked again before shipment and against specification.

The facility is backed up by an engineering department with the capacity of 20-27 qualified staff members. The plant complex is able to design and fabricate the chassis, power train, drawworks and every other larger component of mobile drilling rigs.

Translating these dimensions, capacities and facilities into the space requirements needed to manufacture the rig components which have been suggested to start with, the size of the respective premises amounts to 1/4 to 1/5 of the total area mentioned above.

The basic facilities :

1 work area where structural steel members, sheet steel, tubular steel components and other steel profile parts are cut to size and specified lengths.

1 assembly plant for steel construction work and scaffolding.

1 welding shop.

1 workshop for spare parts manufacturing.

1 open yard space for testing and coating.

Space requirements :

cutting area : 1500 sq.m.
assembly plant : 2500 sq.m.
welding shop : 1600 sq.m.
workshop for spare parts : 1000 sq.m.
open yard space : 5000 sq.m.

Total area : 11600 sq.m.

which equals 2-3 acres.

Personnel requirements :

cutting area : 5
assembly plant : 20
welding shop : 6
workshop for spare parts : 10
open yard area : 4

Total : 45.

This figure does not include overhead personnel, administrative staff, and personnel of the engineering department.

Machinery, respective workshop equipment, lifting facilities and other important installations will be discussed in the following paragraphs which cover the different sections of the manufacturing complex in more detail.

The manufacturing of tripods and telescopic pole type masts can be carried out immediately due to the simple construction of these components and the common steel quality of the used members.

Figures are given in the technical section of this report which show exactly the components in operation. In this respect it can be stated that almost all components of a cable tool rig should not present any problem for local manufacturing,

If production facilities for complete rig components are not feasible immediately due to any arising obstacles, the basic approach for entering the market of manufacturing of drilling rig components should be directed to the setting up of assembly plants or to the establishment of maintenance and repair workshops. The proposed components which have been suggested to concentrate on in the previous pages match very well with the planning of an assembly plant as a first step to commence the new project.

4.1. The Assembly Plant

The Assembly plant may be erected either on a new site, or in an area opened for industrial development already, or within an existing industrial complex which requires an expansion of the present facilities only. Outside consultation on the establishment of an assembly shop is recommended but not absolutely necessary.

Rather important are successful negotiations with international rig manufacturers or drilling contractors about assembly, service and maintenance contracts. Being awarded with a respective order entails an immediate technical and technological information flow to the operation of the shop and forms the basis for further advancement and experience.

Upon successful execution of such a project the accumulated know how, experience and technology leads eventually to licence agreements with the world's leading drilling rig manufacturers.

4.1.1. Size, outfit, equipment, machinery, etc. -

of an assembly plant may be outlined in the following example :

The proportions of the dimensions and sizes of open yard area and indoors space depend largely on the climate zone of the respective plant location. Two thirds of the assembly work is done, for instance, in the oper yard space of an assembly plant situated in the south of the United States.

It is most preferable to determine the location of the shop to an industrial area with a certain existing infrastructure or to an area where industrial development has been planned and partly established already.

Considerations on transport facilities such as the availability of railway tracks, condition of roads, presence of docks (in case of a seaport) etc. are of decisive importance when determining the location of the shop.

Assuming the main activity of the shop is restricted to the assembly work of the previous mentioned rig components, the total area required amounts to about two to three acres (8000 to 12000 sq.m.) This figure includes office buildings, work- and machine shops, storage area, open yard space, coating facilities and transport facilities (ramps, loading areas, crane ways, etc.).

The inside construction area may occupy approximately 3000 sq.m. to 4000 sq.m. of assembly and welding area, depending on the geographical location of the shop as already mentioned, and approximately 1500 sq.m. to 2000 sq.m. of machine shop space. The yard space should provide ample room for storage and testing.

An additional shop on the same premises should be established under roof to provide for the accessories and attachments as stated previously to the rig components assembled in the plant. This shop might need approximately 500-700 sq.m. of indoor working space.

Machinery and equipment for the assigned workshops :

Cranes : normally one per workshop installed with a span of approximately 10-15m. The load capacity of the crane figures to 5 metric tons. The crane is used mainly for pick-up jobs, feeding the machine tools and serving the shelves.

One lathe is normally sufficient to back up this kind of assembly work which the shop is supposed to carry out. Some considerations may be given to a hollow spindle lathe to machine tubular parts and goods for the mast or derrick. A center lathe might be preferable in case of remachining and fabricating smaller parts. (3-4m long).

Four welding machines are normally required to meet the demands of the assembly section and to cope with the work of the other departments. In some shops one or two protective gas welding machines can be found. In addition there are two to three transformer units. Consideration should be given also to the acquisition of one or two automatic welding units which increase the accuracy of welding work and quality of the weld remarkably. Autogenous welding equipment has to be included to complete the requirements of the welding section.

A cross roll tubular parts straightening device might be of particular interest to add to the machinery palette after two to three years of operation of the plant.

One or two steel saws and cutting equipment are essential in order to back up the work of the assembly section.

Three to four hand grinders and one grinding machine, permanently installed, may complete the grinding facilities.

The acquisition of a bending-off press is absolutely recommended to improve the efficiency of the shop.

The amount of necessary hand tools and tool kits depends of course on the quantity of work forces who are employed in the different shops.

The warehouse has to supply to the assembly section all necessary spare parts and items which are requested for the bolting and pinning of the different components. A domestic spare parts manufacturing program should be initiated to deliver the more simple items on a continuous basis to the plant. The administration of the inventory is very important and needs to be controlled very thoroughly. Comments on the domestic production of inventory are furnished later in this paragraph.

A quality control and inspection department has to be established and furnished with up to date inspection equipment to meet the standards of the international water well industry specifications based on the instructions of the water well drilling contractors association. The department has to be manpowered by experienced and capable staff to furnish an accurate and reliable inspection service. The quality control department has to be equipped with :

- magnetic particle inspection device (known as Magnaflux).
- metallurgical laboratory featuring :
  - tensile testing
  - hardness testing
  - impact testing
  - fatigue testing
  - chemical analysis device

Recommended personnel requirements :

- 1 Plant Manager
- 4 Administrative Staff
- 2 Shop Managers
- 4 Shop Foremen
- 6 Welders
- 1 Lathe Operator
- 6 Steel construction assemblers.
- 5 Helpers (including Fitters & Mechanics).
- 2 Quality Controllers.

The example illustrating the equipment and manpower needed to operate an assembly plant is based on averaging the assets and quantity of people of a couple of shops which are performing in this kind of operation in the south of the United States. It is obvious that requirements for manpower and machinery are subject to variation and alterations from area to area. The comments should furnish a guideline to enable an estimation of the funds needed to invest for the necessary capital expenditures. To come up with an estimated figure of the total cost of such a project is very difficult to define without particular details and information on the conditions of the area and the existing infrastructure.

4.1.2. Workshops

To focus on the workshop which is supposed to supply certain necessary attachments and accessories as already described, to the assembly plant, the following equipment can be detailed :

- Two or three hand grinding machines.
- One or two steel saws.
- Autogenous welding units plus accessories.
- Two small drilling machines.
- Cutting equipment, vices, work benches, hand tools.
- An overhead crane with the capacity of 3 metric tons is absolutely sufficient.
- The installation of an air compressor is highly recommended actuating hand tools, vices, etc. and to be used for various applications. The capacity of the air compressor should be around 750 l/min operating at 10-11 bar.

Recommended personnel:

- 1 Supervisor.
- 3 Mechanics
- 3 Welders
- 4 Helpers

This kind of workshop may be the first initial nucleus to start manufacturing small and simple parts such as accessories to the mast or carrier, which are attached to the constructions and units during assembly work. This basic 'production unit' has to be considered certainly as the initial step into the overall new project by taking into account development countries entering a branch of industry without having any previous or preparatory experience and exposure.

Considering this kind of workshop as the first attempt to establish successfully in the new product lines, the assembly plant has to be focussed on next as the second important approach to attaining the final objective of manufacturing rig components.

In some areas where certain capacities of machine shops are existing already, experienced personnel up to a certain level are available, and technologies are more or less advanced in metal working and machining processes, the establishment of a repair, maintenance and overhauling facility should be given high priority.

4.2. Repair and Maintenance Shop

The shop functions primarily as a repair and overhaul facility for masts, carriers bases and piping for mud circulation.
Further activities will be assigned to the shop after progress has been achieved in training of personnel, implementation of new

technologies and availability of up to date machine tools.

Main functions of the shop :

- Cleaning and preparatory work of delivered rig components.
- Disassembly work.
- Repair or replacement of damaged parts.
- Manufacturing of parts to a certain extent.
- Re-assembly work.
- Testing and inspection.
- Coating and crating (tentative).

As an example, a repair and maintenance shop for rigs and rig components located in Germany has been selected :

Total Area of Workshop and Open Yard : approximately 4-5 acres (16000-20000 sq.m.)

The location should be served by a railway track to facilitate transport and shipment. In case the shop is located close to the water front, port facilities such as docks, piers, etc. should be available with easy access. The area around the shop has to be developed with regard to roads, loading ramps, sewage system, power supply, etc. Inside the industrial area there should be easy access to all shops and open yard space.

The workshops under roof occupy an area of 3000-4000 sq.m.

The shops are equipped with overhead cranes showing capacities of either 5 metric tons, or for feeding the machine tools and picking up lightweight parts, 3 metric tons. The span of the cranes varies from 10m. to 15m. Basic machinery and equipment has to be acquired to generate efficiently milling, shaping, grinding and lathe operation capabilities.

The following machine tools are operated by the repair facility :

- 2 Center lathes (bed length approximately 4-5m.)
- 1 hollow spindle lathe (optional).
- 5 - 7 welding units, including equipment for arc-air, automatic feed and torch welding.
- 1 hydraulic press with a capacity of 150 metric tons (optional)
- 1 milling machine (optional).
- 1 horizontal boring mill (optional)

- 2 radial drilling machines (optional)
- 2 small standard drilling machines
- 2 steel saws
- 1 grinder
- 5 hand grinding machines
- 1 shaping machine (optional).

The equipment or machinery marked (optional) can be found in mostmachine shops within the water well drilling industry. Referring to the type of repair shop which has been suggested to start with, certain types of machinery are not necessarily required at the beginning of the operation as the shop is supposed to service a limited quantity of components only. For future planning and enlarging the shop's capacity, the additional machine tools have to be taken into consideration to be put in place.

The shop has to administrate a decent amount of spare parts to back up the operation. Equipped with the above listed machinery, the shop is absolutely in the position to manufacture most of the needed spare parts on the spot.

A large part of the inventory consists of raw material (profile structural steel members, sheet steel, etc.) and semi finished parts to repair the suggested components.

A great deal of emphasis lies again with the quality control and inspection department. Specifications and standards are defined by the respective regulations which it is mandatory to follow. The department has to be equipped with modern and up to date inspection facilities meeting the requirements of the water well drilling industry. The most important equipment which has to be available is quoted as follows :-

- Magnetic particle inspection device (Magnaflux)
- Appliances to test tensile stress, hardness, yield point. Impact testing and fatigue testing device.

Certain rig manufacturers have routine testing procedures and quality check-ups. The frequency of quality control and inspection is additionally set out by the regulations. When servicing the rig components all instructions and specifications with regard to quality control and inspection have to be followed by the repair shop accepting the work and the owner of the rig equipment has to notify the workshop about common or usual practices which are part of his company policies.

Recommended Personnel requirements :

- 1 Shop Manager
- 8 Administrative Staff
- 2 Shop Superintendents
- 4 Shop Foremen
- 9 Welders
- 6 Lathe Operators
- 2 Milling machine operators.
- 6 Tool Assemblers
- 6 Mechanics and Fitters
- 7 Helpers
- 3 Quality Controllers.

The personnel requirements depend mainly on the quantity and type of machinery installed. The given example assumed 20-30% more personnel taking into account the amount of equipment listed before. It has to be conceded that the amount of personnel required to achieve a certain output varies considerably when comparing different areas.

It is advisable when starting with the repair shop to focus first on the more simple and easier maintenance jobs and to concentrate on development programs like training, additional machine tools acquisition, technological sessions etc. to necessitate fast progress and to increase the diversity and versatility of the repair work of rig components. What should be considered is a steady advancement of the shop to meet also all kinds of small modifications of components which might be necessary especially in certain remote drilling locations.

The repair shop needs a well kept stock of spare parts from which most of the parts, due to the installed machine tools, can be manufactured by the same facility. Again, we have to bear in mind the rig components which have been suggested as the first technical project with regard to assembly, maintenance, and repair and finally domestic manufacturing.

4.3. Spare Parts Manufacture

The spare parts to be considered primarily to produce first in different dimensions and sizes may be listed as follows :

- bushings, bolts, nuts, joints, rectangular/triangular plates, pins, sleeves, clamps, girders, structural steel members of different profile, web parts, angle irons and pivots.

Aside from the girders and other structural steel members which have to be supplied from the rolling mill, the spare parts to begin with require neither sophisticated machinery nor special steel qualities. Furthermore, the listed parts do not need any additional treatment where special and very advanced technologies are involved, such as

carburizing, coating or heat treatment.

A machine shop housing approximately 1000 sq.m. to 1500 sq.m. under roof provides ample and adequate space to produce the previously specified spare parts or inventory items.

To go into manufacturing, one or two center lathes, one milling machine, two drilling machines, cutting equipment and standard workshop tools (like hand grinders, welding units, etc.) are absolutely sufficient to operate the shop satisfactorily. A hydraulic press, casting facility and induction furnace are not required in this first stage of manufacturing spare parts. The addition of new product lines of spare parts, however, to furnish other rig components may necessitate the installation of such new facilities and equipment.

The personnel requirements of this kind of production shop amount to approximately 20 people, including :

- 2 Lathe Operators
- 2 Welders
- 8 Mechanics and Fitters
- 4 Helpers
- 2. Machine Operators
- 2 Quality Control Inspectors.

As outlined before, here again the quality control and inspection service is an important and integral part of the total production process. Inspection methods and equipment correspond in general to the set-ups of the assembly plant and the repair shop, as previously commented upon. The spare parts manufacturing facility needs the back up of an engineering department which takes care of the design, observation of specifications (like instructions of the industry), parts drawings, parts modifications, parts identification and quality control.

Five or six people, including draftsmen, should be enough to manpower the engineering department during the initial phase of operation. Considerations should be given also about integrating an R&D department from the start for further manufacture of spare parts used within other rig components.

4.4. Summary

Summarising the suggestions and alternatives presented in this chapter, the following conclusions can be drawn :

4.4.1.
As an immediate plan of attack, to launch the manufacturing of drilling rig components, mast, base of carrier, support for mast and units of the circulating system have been selected and are given first priority on which to focus.

4.4.2.
An assembly plant is established to enable the first steps of engagement and involvement to participate in the construction work or scaffolding techniques of the assembly of rigs and parts of the carrier. This includes the local manufacturing of simple accessories and attachments to the mast and carrier which have been outlined. Furthermore, coating work, shot peening, rust removal and galvanizing can be accepted and carried out by the same facility. Assembly of discharge and return lines and tanks represents another main activity of the assembly plant.

4.4.3.
A repair and overhaul shop is set up which could be included in the assembly plant location or is considered as the first facility of that kind to start entering the repair and maintenance business of drilling rig components. The shop might start with simple repair work on masts and carriers and overhauling of tanks, and piping. Advancing in the application of technologies and tooling, the shop might undertake more and more complex and larger repair work of different rig components. The workshop might be given preference over the assembly plant in some areas due to the existing infrastructure or the different working conditions. The nature of a service contract, licence agreement or even a joint venture business is definitely the decisive factor for the type of activities of the future facility. In other words, the preference to start with a repair shop or an assembly facility depends mainly on economical, strategic and financial facts.

4.4.4.
The manufacture of spare parts for rig components is launched. This set up may go along with the repair shop as a back-up to replace damaged or destroyed parts. The first emphasis lies with the manufacture of spare parts for the rig components overhauled in the repair shop. Further advancement of manufacturing capabilities may lead to a more and more versatile producer of all kinds of spare parts and to becoming a supplier, on a much larger basis which does not include the back-up of the repair shop only, but the actual delivery to drilling contractors, water well drilling companies and last, but not least, to drilling rig manufacturing companies.

4.4.5.
Out of each of the physical establishments commented on above, might develop the first manufacturing plant of rig components. This does not suggest that the manufacturing of rig components necessarily has to follow that trend. Many factors and local conditions have an impact on the respective industrial developments. In any case, and regardless of what policy might be implemented, the manufacturing facility starts first to fabricate the suggested rig components either independently or within the scope of a joint venture contract, licence agreement or any other form of co-operation or collaboration treaty. In this respect UNIDO can contribute effective assistance to the successful realization of each anticipated project as a co-ordination link between government and industry.

4.5. Intermediate Term Program (Five Years)

Whilst launching the manufacturing of the first rig components or operating the first assembly plant or maintenance and repair shop development programs and initiatives should be promoted to 'look further down the road'. In other words, different and more complex rig components and parts should be studied to be included in the production schedules of respective plants. The basic requirements and certain demands which have to be met, the technical and technological problems which have to be managed and the recommendations to overcome certain obstacles from the drawing board to the first prototype will be illustrated in the following paragraphs.

4.5.1. General Topics

The overall objective may be defined as creating an engineering design and development, training and industrial liaison program with regard to the innovation of product lines.

Furthermore, to achieve a meaningful inter-linkage in the work program between design/development and production.

In-service training of local technical personnel and trainees in various aspects of rig components design, and manufacture. (As part of an overall training programme and activity).

To establish a local technical advisory committee for supervision and co-ordination of technical projects.

The expansion and extension of existing facilities, the lay-out of new manufacturing plants, the establishment of R&D departments or centres and the planning of training programs depend on the quantity, volume, different designs, complexity, and economical feasibility of components which have been decided upon to manufacture. To finance projects and to plan on investments, careful consideration has to be given to the economical justification of the expenditures for the respective product lines. The basic deliberation has to be referred to as "what can the domestic industry supply and manufacture right now". In other words, what and how many contributions can be made at present without any additional investment involved and what has to be imported or what investments are needed for manufacture on a local basis. The study provides suggestions and recommendations for these considerations and offers practical solutions. The final decision, however, is up to the local executive authorities.

Before proceeding with the discussion on the different programs and physical facilities this insert seemed to be important to mention.

Aiming for the manufacture of rig components, the present existing facilities have to be examined on their efficiency and condition. If the results are not satisfactory, investments should be made for additional machinery, building facilities, handling equipment, yard space, etc. If the existing infrastructure is not sufficient a new industrial complex has to be planned and established. The project has to be supervised by a local technical and economical advisory committee.

The requirements for domestic existing facilities may be commented upon in the following :-

- workshop and plant buildings made of steel construction and pre-fabricated elements.
- crane, and all kinds of lifting facilities.
- transport facilities.
- machine tools, such as lathe, milling, drilling, shaping and grinding machinery.
- electric welding equipment.
- work benches, vices, hydraulic make-up and break-up equipment, steel saws, cutting equipment, flame hardening facilities, polishing and scraping tools, air compressors and lines.
- storage place for raw material, inventory items, semi-finished goods, tools and open yard space.

The described equipment above has to be available in order to produce further basic components.
of a few small machine shops to get the spare parts supplied.

To manufacture more advanced rig components such as mud pumps, drawworks and rotary table parts, the following facilities are required :-

- efficien' 'orge plant and foundry.
- heat treatment facilities,
- alloy steel supply.

Furthermore a reliable back-up is needed of :

- bearings manufacturing plants.
- seals and packing manufacturer.
- chains manufacturing shops.
- transmission belts producers.
- sprockets and gear parts manufacturer.
- electric motors assembling companies.

to supply the necessary inventory, spare parts and sub-components.

An intermediate term program has to take all these necessary requirements into account in order to provide the establishment of plants and factories or the enlargement of present facilities. The required level of employed technologies has to be achieved in order to operate the planned facilities in an efficient way and tight R&D and training programs have to be worked out to manage the implementation of advanced technologies and to cope with the required qualifications.

4.5.2. Material Specifications and Classifications of Rig Components and Parts.

The following tables provide the necessary informations on the complete production line of rig components with regard to material specifications and classification of components or parts in different categories.

List A. - Most Simple Parts.

Parts Description	Standardization	Material Specification
	(International: INT. API Standard: API. Possible standardization at National level: NAT).	
a) Derrick (Mast)		
Structural steel members : (angle, channel or I-beams)	API	AISI C1015, C1025 Legs : V60/6000 p.s.i. or Ex-Ten 60
Bolts, nuts, joints, plates, etc.	API	AISI C1038, C1042 FK553 (Germany) FKM4653 (Germany)
Hydraulic Cylinders, hydraulic rams	API	AISI TS4140, 4142
Frames	API	AISI C1045, C1050
b) Substructure		
Structural steel members (I-beams, etc.)	API	AISI C1015, C1010 TI Sheet steel.
Bolts, nuts, joints, etc.	INT	AISI C1038, C1042 FK553 (Germany)
Rig Floor elements	NAT	AISI C1008
c) Circulating System		
Mud House	NAT	AISI C1010, C1012
Steel mud pits	API	AISI C1015, C1025

List A. (continued)

Parts Description	Standardization	Material Specification
c) Circulating System (cont.)		
Tanks	API	AISI C1025
Chemical mixing barrel	NAT	AISI C1025
Water Tanks	NAT	AISI C1025
Discharge and return lines	API	AISI C1045, AISI420
d) Auxiliaries		
Utility house, dog house	NAT	AISI C1010, C1012
Stairways	NAT	AISI C1010
Shelters	NAT	AISI C1010
Pipe Racks	NAT	AISI C1015
Truck ramps	NAT	AISI C1015
Guard rails	NAT	AISI C1010
Linings (facings)	NAT	AISI C1012
e) Drawworks		
Mechanical brake	API/INT	AISI C1045, C1050

List B. - Critical Parts

Parts Description	Standardization	Material Specification
a) Drawworks		
Main drum	API	AISI 4337 34CRNIM06 (Germany)
Sand reel	API	AISI 4140, E4137
Catheads	API	Cast Steel Germany : GS45, GS52
Electro magnetic brakes	API/INT	
Inertia brakes	INT	
Hydraulic brakes	API	
Driller's console	API	AISI C1015
Clutches (air/diaphragm)	API/INT	AISI 4140
Transmission	API/INT	AISI 4145, 4142, 4147
Sprockets	API/INT	AISI C1042, C1045
Chains	API/INT	AISI C1045
Shafts	API	AISI 4145, 4142, 4150
Gears	API/INT	Germany : 16MNCR5 AISI L2 case hardened
Housing	NAT	AISI C1015, C1012
b) Crown Block		
Centre pin	API	AISI 4140, 4145, 4147
Bearings	API/INT	AISI E52100, E51100
c) Travelling Block		
Centre pin	API	AISI 4140, 4145, 4147
Bearings	API/INT	AISI E52100, E51100
d) Drilling Line	API	
e) Carrier		
Truck for mobile water well drilling rig or light drilling rig for oil and gas.	API/INT	

List B. (continued)

Parts Description	Standardization	Material Specification
f) Rotary Table		
Pinion shaft	API	AISI E4137, 4140 heat treated
Bearings	API/INT	AISI E52100, E51100
Capsule	API	Germany : GG26 Cast Iron (grey)
Pinion	API	AISI 4615
Table	API	AISI 4340
Seals & packings	API/INT	
Table guard	API	AISI C1015, C1012
Bushings	API	SAE 60446 GX70CR29 (Germany)
Pinion Key	API/INT	AISI 4340, E4340
g) Swivel		
Bail	API	Steel casting Germany : 34CRMO4 AISI E4135, E4132
Gooseneck	API	Germany : GS52
Washpipe	API	AISI 6117, 6120
Packing	API	Teflon - Chevron
Bearings	API/INT	AISI E52100, E51100
Body	API	Steel casting Germany : 34CRMO4 AISI E4135, E4132
Stem	API	AISI 4140, 4142, 4145
h) Circulating System		
Rotary hose	API	
Coupling	API	AISI C1045
i) The Pumps		
Body	API/NAT/INT	AISI 1029 Germany : GS52
Piston	API/INT	AISI 4337 Germany : 34CRNIMO6
Liner	API	AISI 5147 Germany : 20MNCR5

List B. (continued)

Parts Description	Standardization	Material Specification
i) The Pumps (cont).		
Cylinder	API	AISI 5140 Germany : 41CR4
Cylinder Head	API	AISI 5140 Germany : 41CR4
Valves	API/INT	SAE HNV6, EV8, HEV4
Packings	API/INT	Rubber base, plastic base.
Piston rod	API/INT	AISI 4147, 4145
Cross head extension rod	API/INT	AISI 4147
Cross head	API/INT	AISI 4140, 4142
Crankshaft	API/INT	AISI 4130, 4150. case hardened
Pinion shaft	API/INT	AISI 4340
Pinion gear	API/INT	AISI L2 Germany 16MNCR5 case hardened
Pulsation dampener	INT	Steel casting Germany : GS45, GS52
j) Shale Shaker		
Screen	API	AISI C1045, C1050
k) Desander & Desilter	API	AISI 4140, 4130
l) Prime Movers		
(Engine construction)	API/INT	
m) Generators	API/INT	
n) Air Compressor	INT	
o) Auxiliaries		
V-belts	API	
Transfer pumps	INT	

List C. - Components under Licence

Parts Description	Standardization	Material Specification
a) Crown Block		
Sheaves	API	AISI C1043, C1045
Sheave guards	NAT	AISI C1010, C1012
Chassis	NAT	AISI C1015, C1010
b) Travelling Block		
Sheaves	API	AISI C1043, C1045
Sheave guards	NAT	AISI C1010, C1012
Heavy steel plates, and housing parts	NAT	Cast steel AISI5145 GS45 (Germany)
Elevators	API	GS45 (Germany)
Hook	API	Alloyed steel casting
c) Rotary Table		
Master bushing	API	SAE60446 GX70CR29 (Germany)
Kelly bushing	API	SAE60446 GX70CR29 (Germany)
Table base	API	AISI C1025
Studs	NAT	AISI C1015
Rotary Slips	API	AISI C1045, case hardened
d) Circulating System		
Bulk mud storage bins	API/NAT	AISI C1015
Simple mud pumps (for water well drilling)	INT	
Mud gas separator	NAT	Steel casting Germany : GS45
Mixing hopper	API	AISI C1025
Standpipe	API	AISI C1045, AISI420
e) Drawworks		
Transmissions (chain-drive and gears)	API/NAT	AISI 4145, 4142, L2, C1045

List C. (continued)

Parts Description	Standardization	Material Specification
f) Auxiliaries		
Electric cables and lines	NAT	
Rig lights	NAT	Sheet steel, low grade.
Small electric motors	NAT	
Rig floor tools	API	AISI A7, A9.
Off-floor rig tools	INT	AISI A4, A7.
Fans	INT	AISI C1015
Choke manifold and high pressure hydraulic lines	API	AISI C1050
Centrifugal pumps	INT	

The abbreviation mark API/INT means a combination of recommendations only by API and International standards which are more predominantly in use nowadays.

Components marked with API are defined exactly by the API specifications and it is mandatory to follow them.

4.5.3. R&D Facilities

Planning on the manufacture of more sophisticated rig components and spare parts or focussing on the repair and maintenance of engines, drawworks, rotaries, etc., the establishment of R&D centres within the domestic industry is an absolute necessity. The same statement applies to joint venture projects, service contracts for assembly and maintenance of rig equipment or manufacturing under licence.

The following comments include details about set-up, operation and functions of an R&D facility.

4.5.3.1. Activities of an R&D Centre

The progressive development and innovation of special product lines requires the back up of an effective operating R&D facility. The R&D work includes especially the technologies involved, the machine tools to be employed and a solid analysis of raw material to be used. Topics of engineering R&D activities are itemized as follows :-

- To check on qualities, grades, physical properties, etc. of domestic steel supply. This involves steel analyses, change of working processes, system changes, improvement of technologies, etc.

- To elaborate instructions about material selection, material processing, material finishing and material testing which have to be followed as standard by the domestic industry.

- To check on standard of technologies and to work out programs for improvements and innovations. This involves investigating heat treatment facilities, other steel finishing processes, (coating, flame hardening, etc.), foundry facilities, forging plants etc.

- To analyse status of available machine tools with regard to capacity, attachments, condition and time in operation.

- To list up to date machine tools and equipment for improvement of technologies and capacities.

- To investigate, to correct and to improve actual machining processes, finishing processes and working procedures within the metal working industry.

- To establish and develop a file of designs, detailed drawings and numbering of parts and components (including inventory items).

- To initiate technological pilot tests and to supervise the progress and exercising of the same.

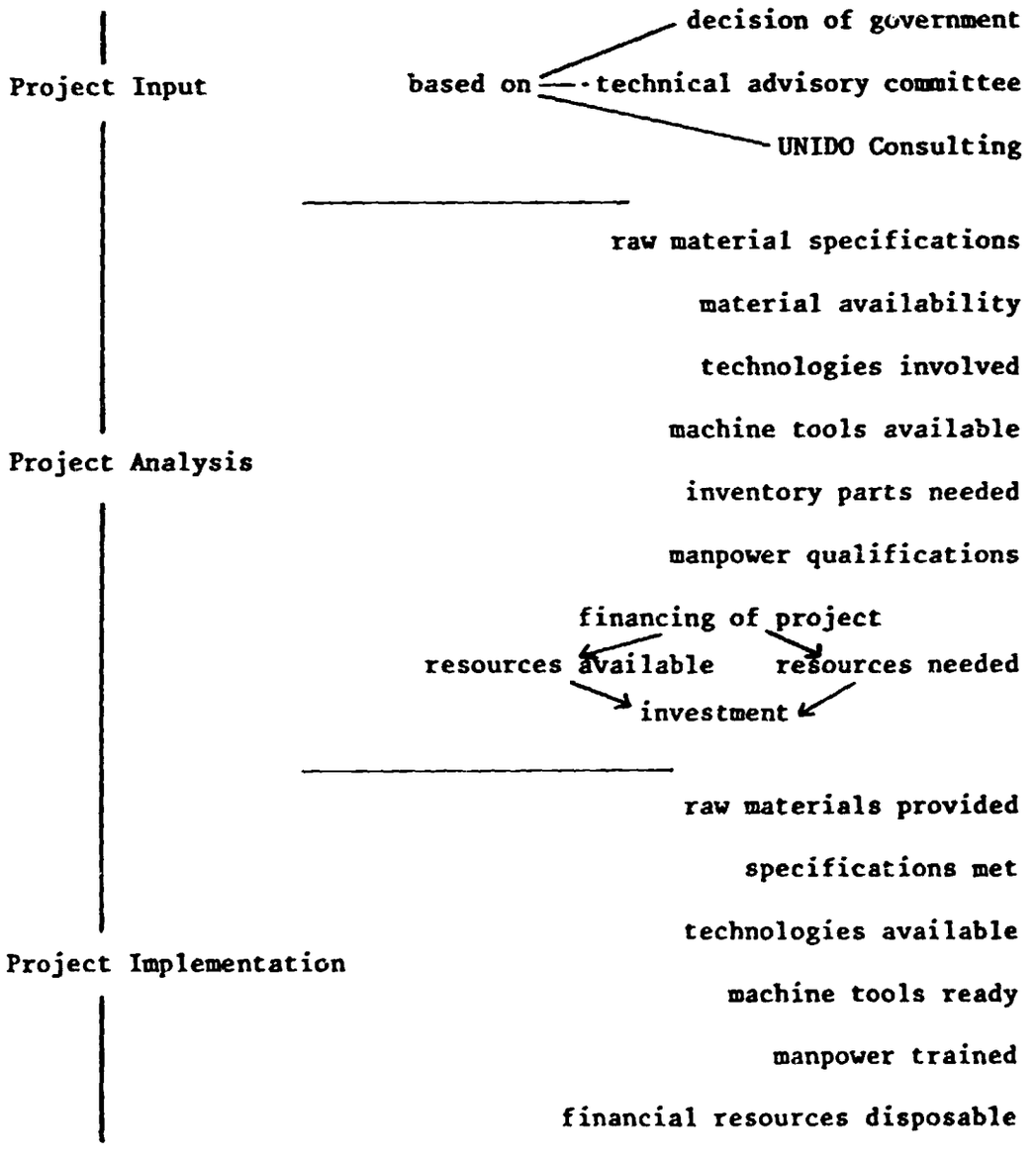
- To follow up on development of prototypes.

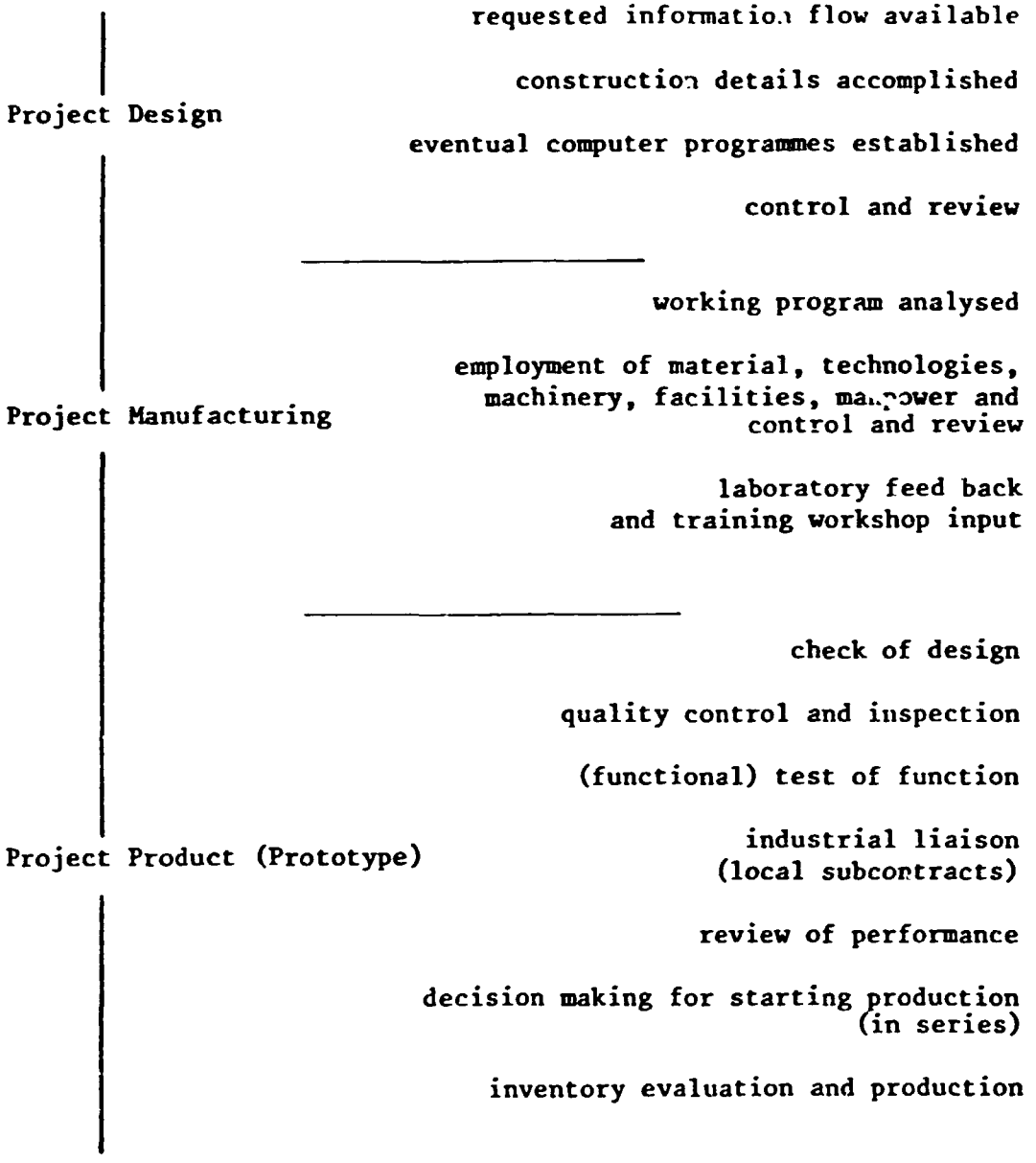
- To establish a "training centre" including a laboratory and training workshop featuring a test drilling rig to provide for tests of prototypes and samples.

- To extend R&D work gradually to sophisticated parts and equipment to reduce the imported parts list and increase the local manufacture or local manufacture under licence items.

The R&D centre is a high priority concern. The proper function of this engineering set up determines the successful development of new product lines for mass production.

A schematic diagram may illustrate the functional activities based on given objectives of an R&D centre :





In case of any obstacle to the explained procedure, corrective and precautionary actions have to be established to keep the continuing plan of attack on stream.

A few examples may illustrate the possible problems and hold-ups:-

a) Raw material specifications not achievable :
   - analysis of obstacles
   - solutions through local R&D work using established facilities
   - solutions through consultants to suggest follow-up
   - import of material or components needed.

b) Technology level does not meet requested standards :
   - solutions through local R&D work using established facilities
   - solutions through consultants' suggestions
   - import of foreign technology and know-how (manpower, machinery, etc.)

c) Manpower qualifications do not meet requirements :
   - solution through local R&D training centre (employing local and foreign instructors).
   - solution through training programs abroad
   - solution through training programs provided by UNIDO consultants.

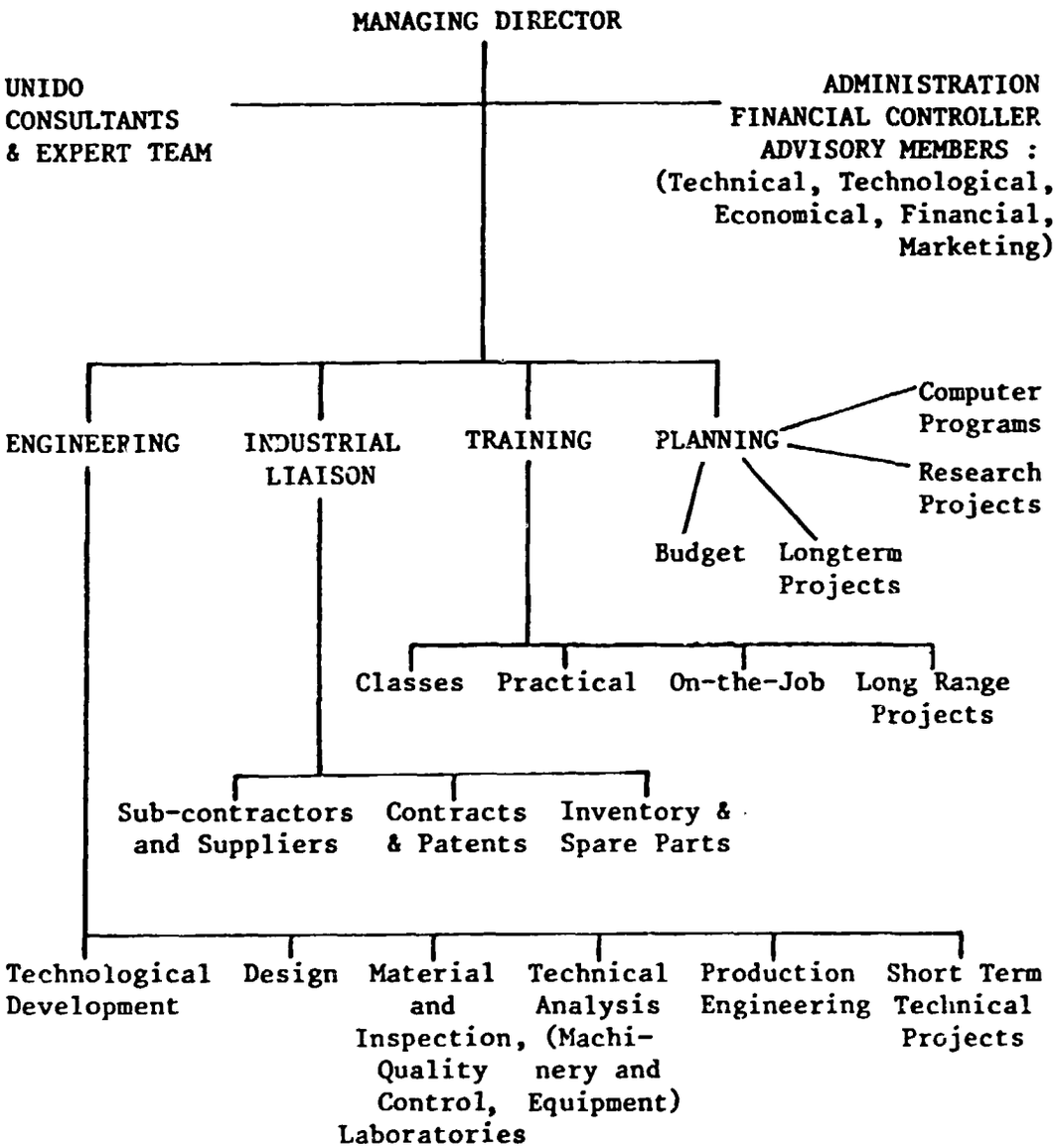
d) Prototype failures :
   - analysis of possible reasons and defects.
   - solution through local R&D quality control and inspection service and expert committee.
   - solution through outside consulting including UNIDO advisory service.
   - solution through technical help from outside experts employed temporarily by the R&D centre.

4.5.3.2. Organisation of R&D Centres.

R&D centres may be established within the specific branches of industry or as a central institution as a national research centre specifically programmed towards the development of rig components. The first approach seems to be more attractive as the respective R&D department or centre within a certain branch of industry may experience a much better information flow and feed-back from the plant as a centralized institution normally does. Furthermore, a centralized set-up involves a very big staff to carry through most of the specific programs.

However, the first proposal requires a co-ordination link between the several R&D set-ups. Regardless of what system will be chosen, these "engineering cells" are to be set up and put in operation immediately. The R&D centres have to be furnished with specific development programs and instructions about the product lines upon which to concentrate. Time frames will be established and the progress monitored. The experts team of UNIDO is recommended to do the leg work to enable the operational start-up of the R&D centres within a very short time (6 months).

Example of an organisational chart of an R&D centre :



4.5.3.3. Working Program of an R&D Centre

After agreement is achieved on which product lines are going to be manufactured, the R&D centre elaborates a working program. The program should include the following details :-

4.5.3.3.1. parts or components which can be manufactured according to existing facilities, qualified personnel and level of technologies.

4.5.3.3.2. parts or components which can be manufactured after two years of R&D work and operation.

4.5.3.3.3. parts or components which can be manufactured after five years of R&D work and operation.

4.5.3.3.1. an immediate file is established for parts drawings, parts numbers, specifications, material qualities, etc.

a special co-ordination department is launched to work out co-ordination plans for the different work processes and for the different manufacturers in case there is more than one branch of industry involved in the project. The plans include timetables, specifications and standards to be met.

a team of engineers supervises the production until the final product (prototype) is manufactured.

quality tests and inspections are carried out during the whole production process and suggestions for improvements are implemented immediately or after the prototype is finished.

prototype tests and final inspections.

training programs, and practical training within the training workshop, are arranged and conducted simultaneously. The programs include already preparatory topics for the development of components or parts of category 4.5.3.3.2.

4.5.3.3.2. the design and parts drawings are accomplished.

review and improvements.

inventory items identified and parts file established.

material requirements investigated.

material supply according to requirements specified to steel industry.

improvements and eventual change of processes implemented (based on "know how" and training sessions).

machining requirements investigated.

machining technologies implemented according to specified requirements.

improvement of facilities and work processes, input from factory.

machining capability established.
(training sessions and instructions from outside sources adopted).

co-ordination of different departments and branches to manufacture prototype.

inspection and quality control in every manufacturing unit and phase during production process.

co-ordination and evaluation of results involving "back to the drawing board" and "go ahead".

co-ordination plans and schedules have to be observed and reviews have to be based on operational reasons for eventual delay.

supervision of team of engineers during the whole production period.

suggestions for improvements are implemented during the respective manufacturing processes or phases and integrated in the manufacturing progress.

prototype tests and final inspection.

A certain workpiece undergoes quite a few processes and procedures until the final end-product is accomplished. Especially in the case where a prototype has to be manufactured, the expenditure on material, technologies involved, working processes and testing procedures can sometimes be extremely time consuming and costly based on technical failures and possible reversals. In order to avoid such cost exposure from the start, a careful planning, detailed working schedule and inspection or control set up after each working process have to be established.

Certain product groups need parts and small items from different sources of supply which emphasises the importance of planning and scheduling to manufacture the products in time.

4.5.3.3.3. the comments made in category 4.5.3.3.1. and 4.5.3.3.2. apply mainly to the product lines under category 4.5.3.3.3. with the only exception that within this section a larger time factor is involved.

A test rig is recommended to be installed in an open yard to check and test prototypes or finished parts.

the listed comments comprise the main activities of a respective work program, but cannot itemise every single step as it will be up to the local management of an R&D centre to run the operation as efficiently as possible and to take into consideration local conditions and circumstances. This does include also necessary alterations of programs or a different approach.

4.5.3.4. Training Programs and Personnel Recruitment

The training sessions and programs are an essential part of the activity of the R&D Centre. UNIDO can assist and contribute to the successful training of personnel in a very effective way. The appointment of consultants conducting training sessions and several missions advising on practical training in the training workshops definitely speed up the progress in obtaining qualified personnel.

The R&D centre needs very qualified engineers and draftsmen to cope with the development of different projects. Engineers with mechanical and metallurgical background should make up the basic force. Personnel holding degrees in electrical engineering, drilling engineering and specialists in designing are also required. The centre also needs well trained mathematicians, physicists, stress analysts, machine tools assembler and engine assembler. All key personnel should have 5-10 years experience within the respective industry. Furthermore, laboratory assistants, operators of lathes, welding equipment and machine tools should be hired to manpower the workshop.

4.5.3.5. Testing Facilities

R&D development programs of special parts, such as bearings, packings, seals, etc. should be delegated to the specialised existing branches of industry for further investigation and development. This also applies to sophisticated metal coating processes or metal finishing techniques.

The R&D centre should have ample space for testing purposes equipped with the necessary facilities. This includes material test equipment, inspection devices, chemical detection appliances, etc. Laboratories for physical tests should be available.

As an example, a metallurgical laboratory is equipped with :

- tensile testing
- hardness testing
- impact testing
- metallographic examination
- carbon determination
- fatigue testing
- jominy fixtures
- ultrasonic inspection, etc.

4.5.4. National Technical Cell

Some sort of control function to supervise all these activities is necessary - to monitor the progress, to administrate the financial investments in comparison with the respective budgets, to authorize the necessary capital expenditure and to act as a co-ordination link between different industrial branches. The following comments include the main activities of such an institution :-

Highlights of a "National Technical Cell"

The functions of a "national technical cell" to promote integrated programs of action may contribute substantially to the overall success of the project. The members of this institution have to be selected very carefully to provide excellent assistance and an effective operation for the benefit of the domestic industry.

First of all attention should be given to experts of the metal working and steel manufacturing industry. Personnel experienced in operating and qualifying machine tools should be included as well. Supervision and control of the progress of established development programs should be a further main concern of the "national cell". The promotion of respective programs is recommended to depend on and left to the evaluation and estimation of the experts commission. The respective programs should be furnished with time frames and deadlines in order to speed up the necessary actions to go into production. In case of any major difficulties which might delay or in any way jeopardize the success of a program an appeal should be made to the "national cell" which should provide in return technical assistance or constructive alternatives to lead the program back on stream.

The main activities of a "national technical cell" may be outlined as follows:-

- To be established as a link between the government and the industry involved in the specific project.

- To be staffed with technical experts (required background : mechanical engineering, metal working technology, steel manufacturing techniques, drilling engineering), financial controllers and marketing personnel.

- To conduct and supervise surveys, studies and analyses to render working programmes feasible.

- To establish priorities for implementation of programmes.

- To evaluate funds and investments needed to realize the intended projects.

- To establish budget plans and financing possibilities.

- To control flows of funds and investments to end-user and to monitor expenditures.

- To call out for tenders to domestic industry.

- To set up reporting system and time frames.

- To control progress of promoted programs.

- To co-ordinate industrial projects which involve co-operation of several branches of industry in order to achieve a "community effort."

- To arrange for training possibilities and programs.

- To appoint consultants to assist established programs of action.

- To evaluate and qualify domestic operations for the production, R&D and engineering of rig components.

- To work out proposals for the innovation of equipment and implementation of new technologies.

- To promote new branches of metal working industry.

4.5.5. Summary of Activities to be combined in an Alternative Working Program for a period of five years :

Summarizing the activities to be combined in a working program for a period of three or five years, the following statements can be derived :

- The UNIDO team of experts prepares the study, elaborates a plan of attack and assists with the implementation of working programs for the industry and engineering development programs for the R&D centres.

- The UNIDO team assists with the establishment of R&D centres with regard to equipment, buildings and financial investments.

- The Government promotes several product lines to put on stream based on recommendations by the UNIDO team in conjunction with the local technical and economical advisory committee.

- The industry and R&D centres invest for expansion of facilities, additional machinery, engineering development programs, training centres and recruitment of persornel.

- The Government provides incentives for the local machine shops and smaller companies of the metal working branches to manufacture and supply inventory items, spare parts and subcontracted parts of equipment.

- The R&D centres conduct training programmes, shop and on-the-job training and recruitment of personnel.

- The R&D centres provide designs, working programs, implementation of advanced technologies and feed back on current projects. The production of prototypes is supervised by R&D centre engineers. The co-ordination of work processes and subcontractors is allotted to the responsibility of the centre.

- A team of engineers and draftsmen works out a specific program of a new product line with regard to sizes produced, number and size of inventory items to be manufactured, number and size of spare parts to be made. All items necessary for the product line are designed, recorded, filed, classified in categories and furnished with part numbers and series numbers.

  The design of components has to take account of the rating of different sizes and types, the sizing and dimensioning of parts, the quantity of units of different capacities, the series of production, the multitude of planned sizes and capacities of the respective product line, necessary alterations due to smaller or larger sizes and capacities of components, and redesign of rejected parts by inspection and quality control.

  Furthermore, the sequence of items determined for production has to be planned according to facility capacities and sub-contractors' line-up. Product mix investigations have to be conducted to learn about free capacities and economical utilization.

- The technical and economical advisory committee exercises control and advisory functions. Furthermore, the committee monitors the activities of R&D centres and industry, and checks on the progress made and on the achievement of given objectives. The committee should have the authority to revise the activities and to take corrective action if deemed necessary.

- The UNIDO team is in contact with the committee and should be consulted if problems and difficulties have to be overcome. This includes the mission of technical consultants, training instructors, financial analysts, etc. The UNIDO team should be considered as in a staff position to the committee until the mass production of modules gets under way.

- The UNIDO team advises on new designs of components and the production of the prototypes of critical parts.

- The long range plans have to be implemented already to research for off-shore equipment and modules and for downhole equipment as well. These projects should be focussed upon when R&D centres and facilities are established and operating in the manufacture of rig components.

To get these projects on stream experienced engineering and designing personnel are required.

Emphasis has to be given to training programs tailored to the new anticipated assignments.

On-the-job training has to be organised to prepare technicians for the future jobs they are supposed to assume.

Further case studies may initiate the manufacturing of more sophisticated modules and components and will assist the domestic industry to establish themselves in new product markets.

5. WATER WELL DRILLING RIGS

5.1. General Comments

Everything that has been said about an oil and gas drilling rig applies analogically to the water well drilling rig.. The components of course are smaller, simpler and in most of the cases are of much lighter construction. There are also some design variations from the oil and gas rigs, but the basic concept and equipment stays the same.

A water well drilling rig nowadays is distinguished by its extra-ordinary mobility and easy handling with regard to rigging up and rigging down. All modern water well drilling rigs are truck or carrier mounted, which are equipped with cross-country facilities.

The rigs are assembled by a number of unitized packages which are all mounted to the truck. The components such as pumps, engines, compressors, etc. can easily be interchanged with stronger or lighter units as desirable.

The versatility of the modern rigs makes them suitable for many different kinds of projects and a few changes of units which are easy to arrange provide the means for another type of operation.

Cable tools are still in use in remote areas but they are more and more being superceded by the truck mounted rotary drilling rigs. After adopting the rotary drilling method, the water well industry found that this system was superior to cable-tool drilling.

The API specifications and standardizations do not apply particularly to water well drilling rigs. However, some recommendations which have been established for oil rigs are followed by the water well drilling rig designers.

Most of the components are standardized by national regulations (for example - DIN norm in West Germany, Ö norm in Austria, British Standard in the U.K.)

Water well drilling rigs are of compact design and represent one mobile unit independent of external power supply. The rotary drive consists of either a power swivel or power sub, hydraulically actuated, or a rotary table as on the oil rig. The comparative item used by cable-tool drilling is the swivel rope socket.

The maintenance of a water well drilling rig is directed especially to the carrier and the engines. The proper function of those components governs the whole operation of the rig. The maintenance instructions for the engines, in most cases diesel engines and compressors, have to be given full attention and service schedules have to be carried out strictly on time.

The main components of a water well drilling rig correspond to their bigger counterparts of an oil rig. Most of them are not as sophisticated as the parts of the oil rig.

The rapid development of rig components for the oil industry did of course drag along the design of water well drilling rigs and equipment, but to a certain extent only. The reason for this is obvious. The requirements of oil rigs increased drastically as a function of depth, weights, and anticipated downhole pressures. Furthermore, the development of offshore exploration had a very great impact on rig designs and construction. All these requirements do not have to be met by the water well drilling rig design.

However, water well depths have increased in the last 25 years and the designers were forced to meet the greater demands with regard to rigidity, quality of steel, modernisation, etc. but the lighter constructions and simpler equipment still prevail because of the shallower depths encountered.

The positive impact on the water well drilling industry can be seen in the modernisation of equipment which resulted in a much more efficient operation of drilling water wells and a better utilization of machinery and equipment. This development has to be recognised as a major contribution to the progress of rotary drilling techniques.

5.2. General Lay-out on the Drilling Site

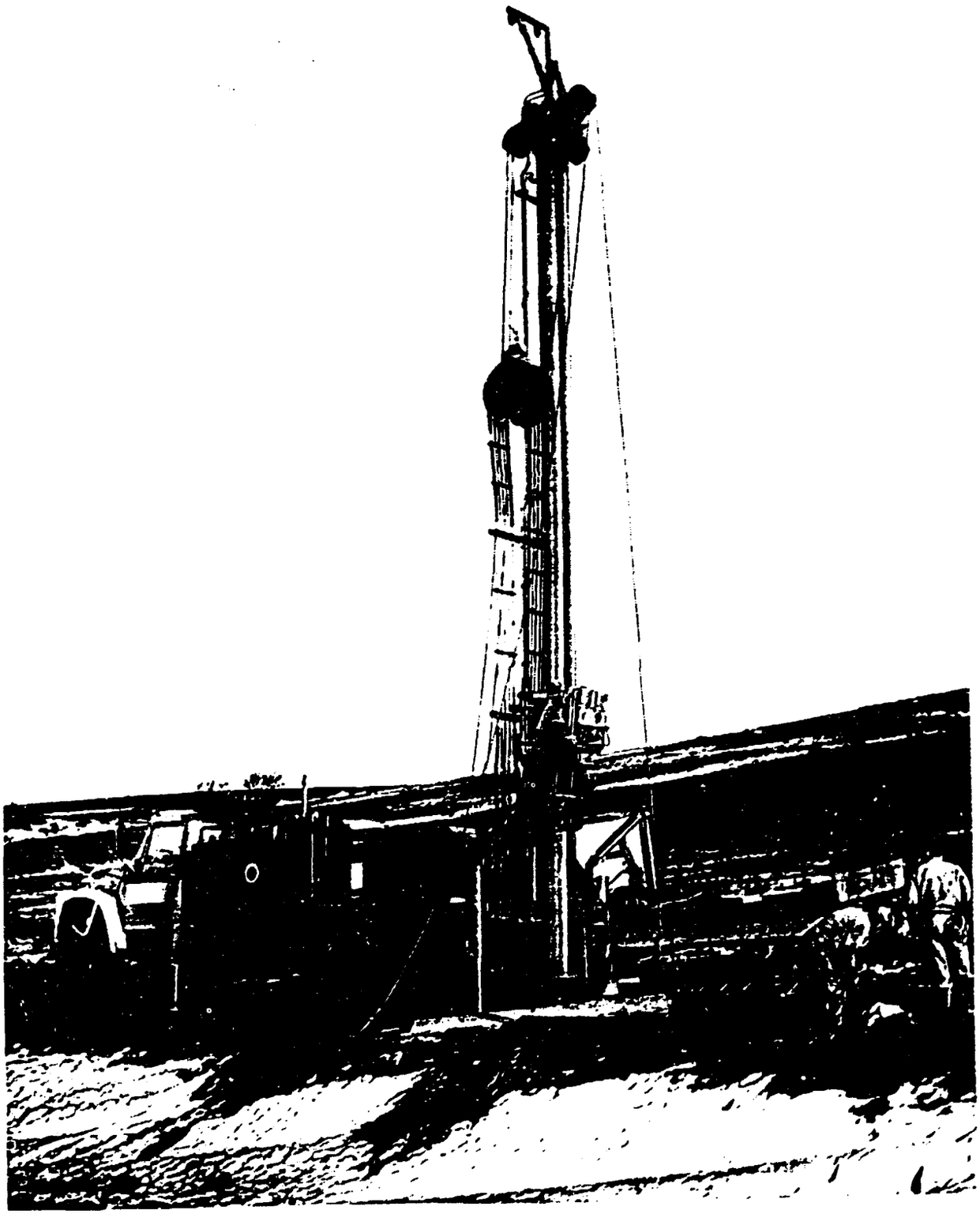


Figure 1.

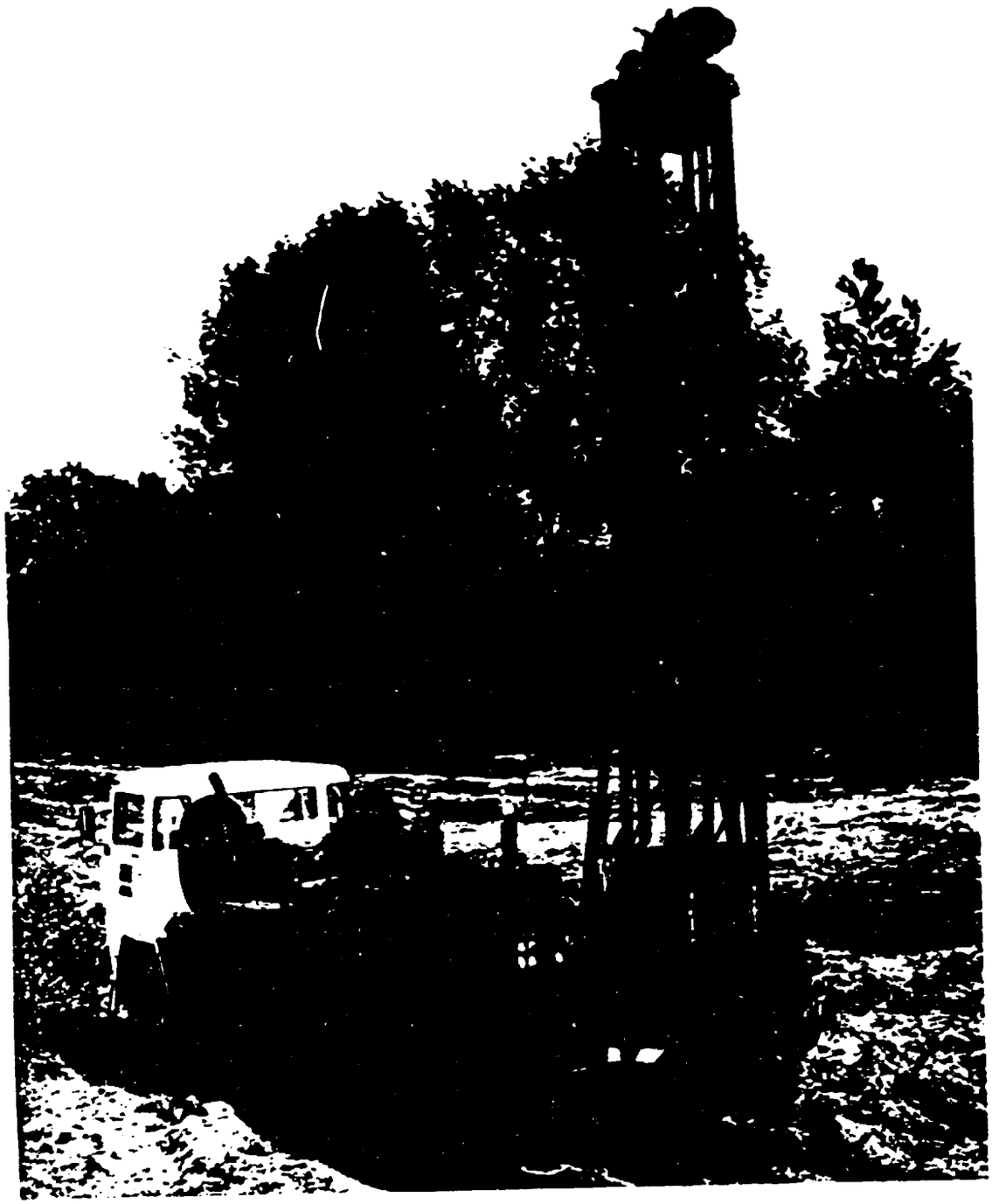
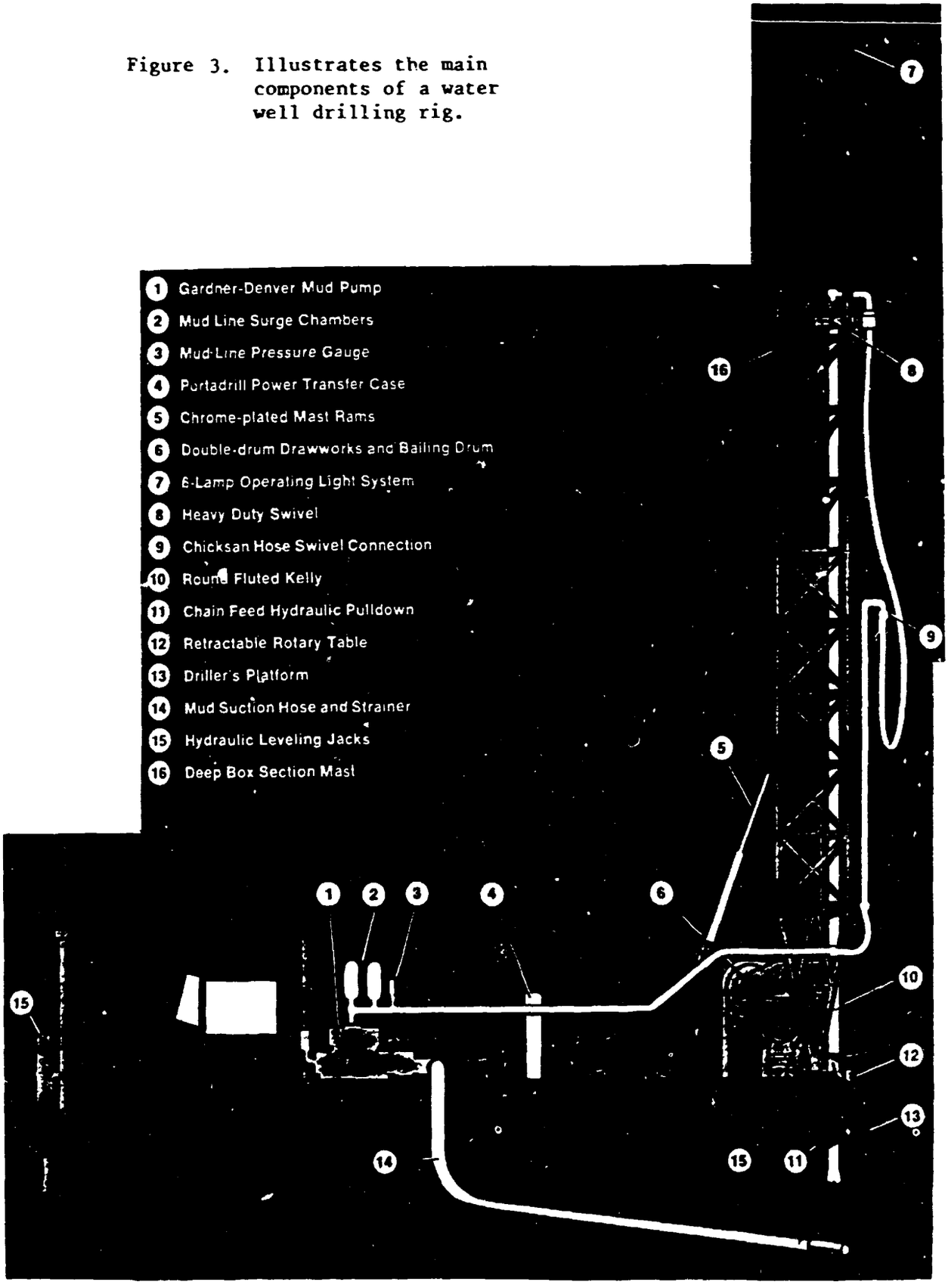


Figure 2.

5.3. General Comments on Equipment and Machinery.

Figure 3. Illustrates the main components of a water well drilling rig.



Flow chart of the DRILLING RIG P 1002

1 Main power unit
2 Gear box
3 Transmission
4 Off-set transmission
5 Distribution gear
6 Switching clutch
7 Piston pump
8 Centrifugal pump
9 Hydraulic pump
10 Gear pump
11 Hydraulic motor
12 Drill head
13 Drill feed
14 Oil/air cooler

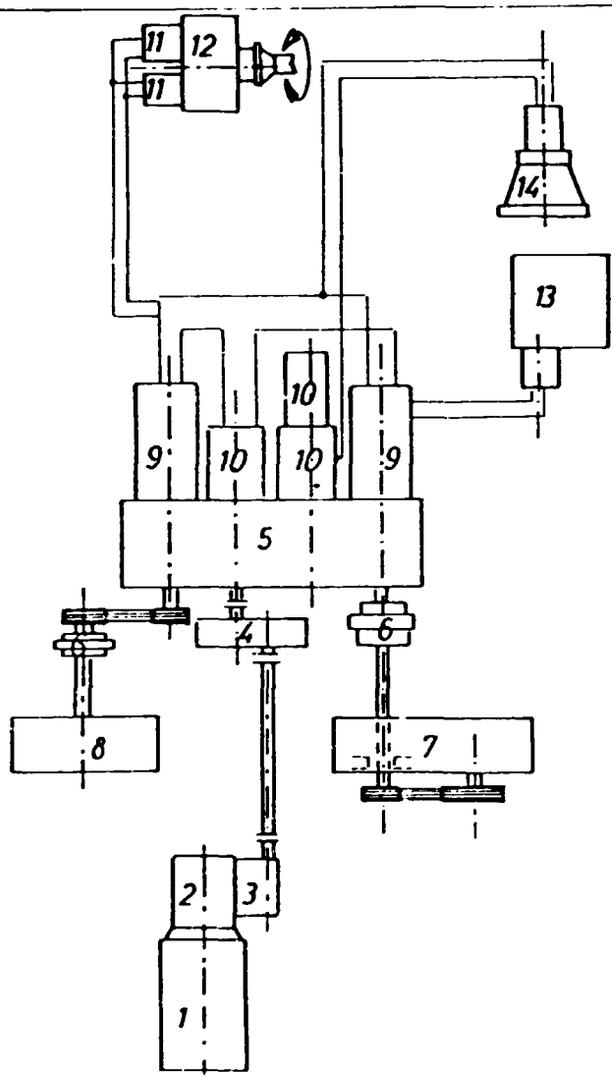
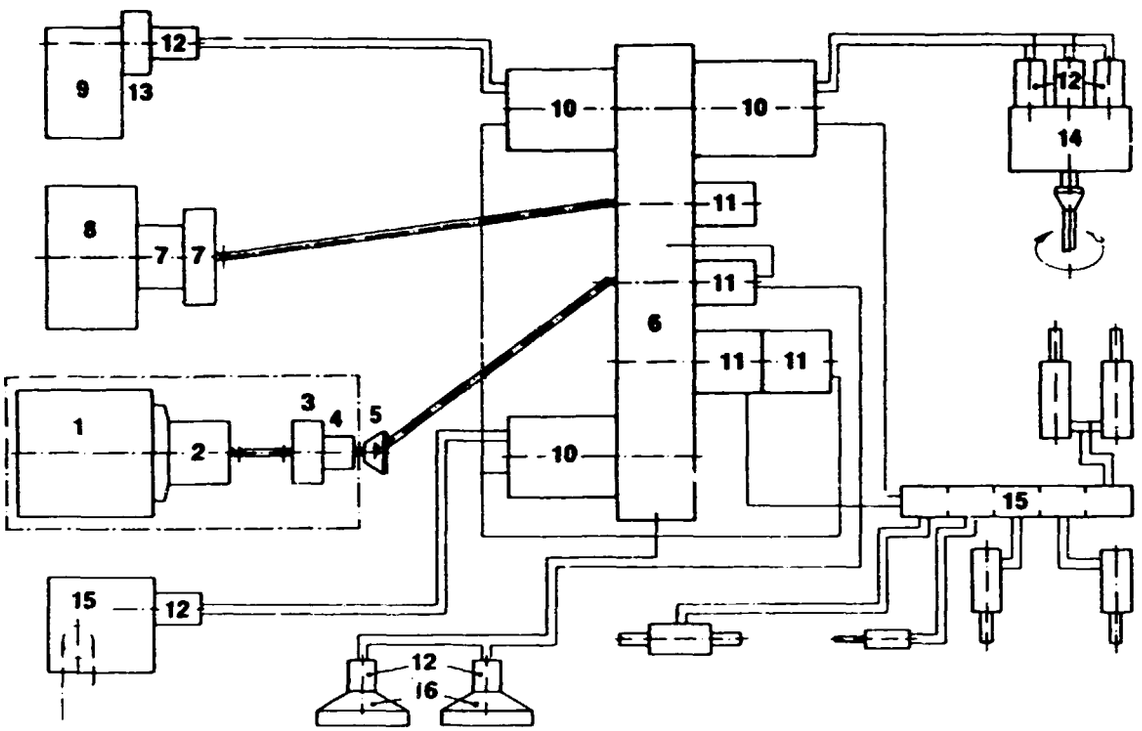


Figure 4(a)

Figures 4(a) & (b) show two typical flow charts for a rig.

Flow chart of DRILLING RIG P 5001



1 Main power unit	9 Piston pump
2 Gear box	10 Hydraulic pump
3 Distribution gear	11 Gear pump
4 Transmission	12 Hydraulic motor
5 Pre-clutch	13 Power take-off
6 Central transmission	14 Drill head
7 Clutch combination	15 Drill feed cylinder
8 Compressor	16 Oil/air cooler

Figure 4(b)

Most of the drilling rigs are constructed according to a building brick system. This enables a correct combination of the several parts needed according to the depth and diameter of the planned drill holes. The trucks or truck trailers are equipped with engines suitable for the required drilling performance.

The truck engine is coupled via a power take-off to a main shaft on the drill which in turn supplies the necessary power to all its aggregates. The trucks are furnished normally with all-wheel drive.

The operation of the drill is easy and without exertion for the driller. Because of this easy handling, only a few minutes are needed in normal conditions to start the drilling operations after the rig has arrived at the well location. In most designs the

derrick is simply and quickly erected with a hydraulic ram after the rig has been stabilized horizontally. Round-tripping the drill stem is accomplished hydraulically in a few minutes. The drill pipe slips of the hydraulic catching system can be adjusted to different diameters of the drill stem. The mud pumps are mounted as low as feasible, directly on the reinforced truck frame. This ensures added suction and pumping efficiency. The pump is driven by a multiple V-belt through a friction disc clutch and torque tube drive lines from the power divider case.

The water well drilling rigs are equipped with rotary tables, mechanically or hydraulically powered, or power swivels and power subs, hydraulically operated. The power transfer case represents the main link to all the rig components where power is needed.

The drawworks of water well drilling rigs show a more simple design compared to oil rigs and are of smaller construction. However, the basic features of a drawworks are retained. The drawworks feature grooved drums (double drum design) for even cable spooling. Powered through a "2"-plate disc clutch at the power divider case through a ring gear and pinion and separate mechanical spline clutches for positive, non-slip engagement. Wrap-around brakes are actuated by eccentric lever controls for ease of use. Double acting hydraulic jacks speed set-up and tear-down time. Normally there is a single front jack mounted in heavy-duty bumper assembly and two rear mounted jacks. A level indicator can be checked at the driller's station.

The selection of the truck is very important for the rating and sizing of the power units and for the load capacity. Trucks which are commonly used and dimensions will be stated later in a following paragraph.

The power train may appear in some models as follows :-

- Power transmitted from truck engine and transmission through automotive type auxiliary transmission full torque top mount to rig power divider.

- Power divider with high speed triple roller chain running on ball bearing mounted heat treated sprockets and shafts in totally enclosed oil bath lubricated aluminium case.

- Power output transferred through end mount clutches with ball bearing throwout collars and universal joint torque tube drive lines to rig components.

1 chassis
2 frame
3 compressor
4 piston pump
5 centrifugal pump
6 winch
7 feed
8 power swivel
9 rope guide
10 catching device
11 rotary tong
12 chain guide
13 mast
14 supporting jacks
15 after cooler
16 air line
17 air container
18 mud line
19 operator's stand
20 hydraulic pump power swivel
21 hydraulic pump feed
22 hydraulic pump winch
23 oil container
24 oil cooler
25 mast raising cylinder
26 feed chain

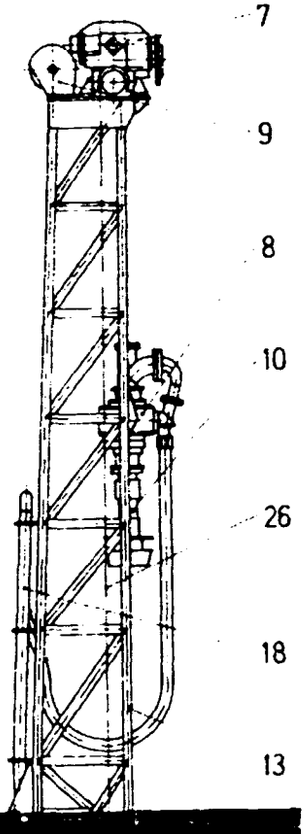
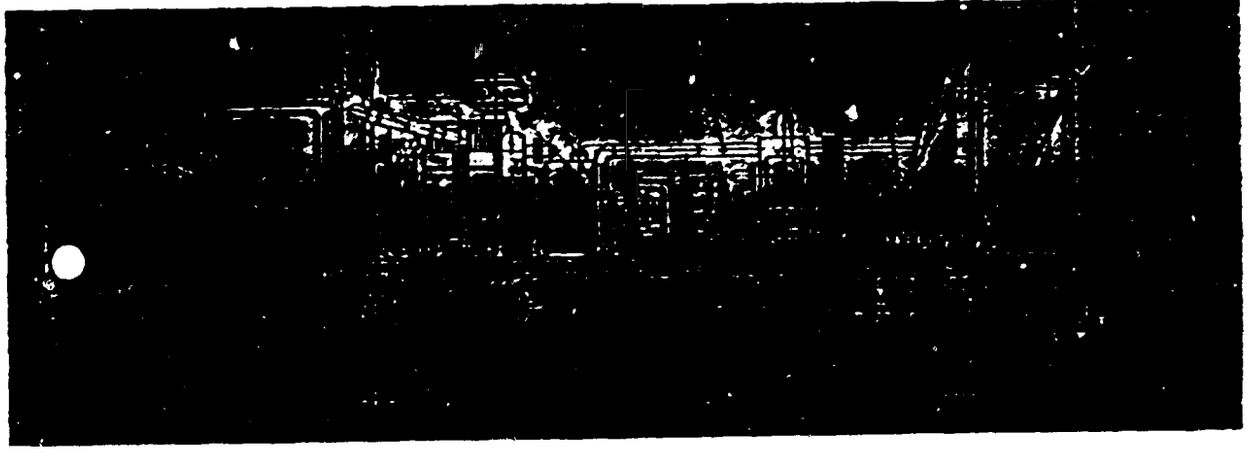


Figure 5. Summarizes the main parts and components of a water well drilling rig.



5.4. Water Well Drilling Rig Units

5.4.1. The Derrick (Mast)

The height of masts for water well drilling rigs varies from 12 ft. to 65 ft. Manufacturers mostly specify the working clearance above rotary table. This is the clearance from the centreline of the crown block sheaves down to the rotary or ground level. Popular sizes are 34 ft., 36 ft., 38 ft., 48 ft., 50 ft., 57 ft. The mast is commonly assembled of electric-welded high tensile strength seamless tubular steel. The basic steel components are rectangular or round shaped. The section design is mostly in box type. Other masts are manufactured in rolled hollow square section. Telescopic pole types are built of similar steel elements.

A hydraulically raisable folding mast of tubular steel is built today by most of the water well drilling rig manufacturers.

The crown block normally has from 2 to 4 sheaves. It consists further of approximately half-inch plate electrically welded with sheaves rotating on heat treated steel shafts with needle bearings or sealed ball bearings design. The design provides for two or four part line string up for kelly and stem drum. Additional sheaves are assigned for pull-down and optional bailing line. Sheaves can be angle mounted for single lines. Two corrosion-resistant, chrome-plated, double acting telescoping hydraulic lift cylinders give smooth control for raising and lowering the mast. The cylinders may be equipped with safety check valves.

In certain designs chains, sprockets and drive for the pull-down operation are built integrally into the mast. This system does not employ the travelling block whilst drilling.

Pulldown : continuous chain feed for full kelly length with 2" pitch single roller chain which is attached to swivel brackets. Powered through a planetary gear speed reducer with air shifter by a hydraulic motor. The metering valves permit variations of pressure to allow hold-back on weight of drilling string. The feed rate is variable from 0 to 16 ft/min depending on formation hardness and pressure selected. The pull-down weight is adjustable from 0 to 30,000 lbs. An optional pull-down motor for faster pull-down speeds can be installed.

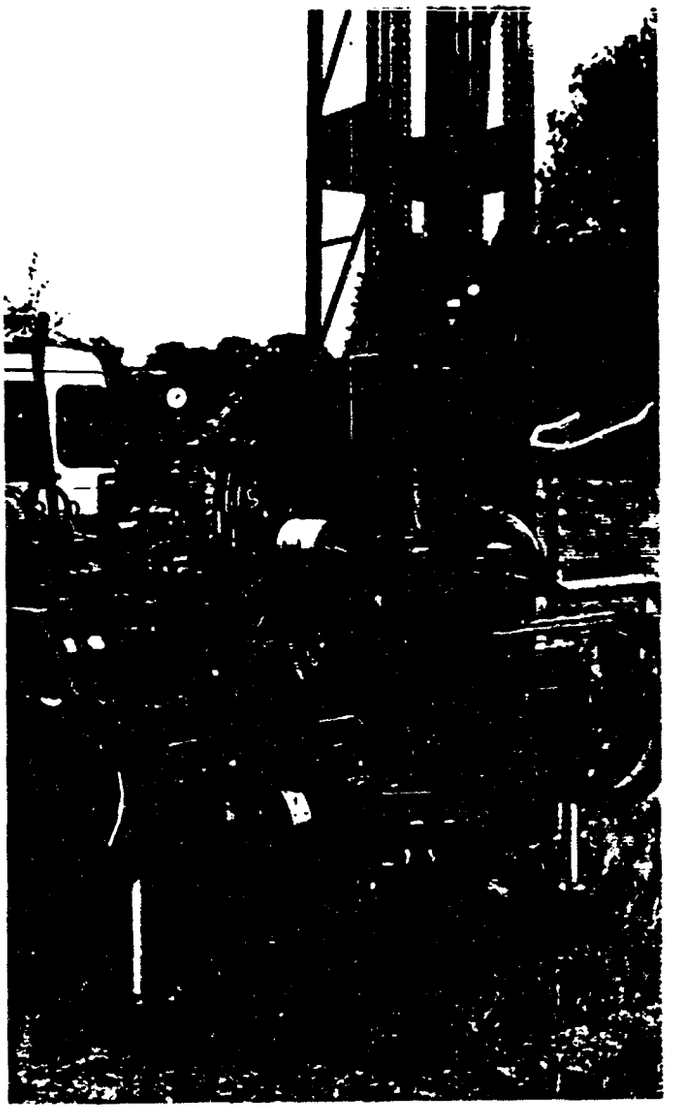


Figure 6. Shows the pull-down chain drive.

5.4.2. The Pumps

Water well drilling rigs are equipped either with centrifugal pumps or with duplex, single or double acting piston-type pumps as discussed in the oil rig section. Pump outputs up to 600 g.p.m. are normally sufficient and the size depends on the carrier used. The mud line pressure gauge shows the same design features as the gauge to be found on an oil rig. In the case of air drilling, a compressor is installed instead of a pump. The pump is V-belt driven from the power divider case through a mechanical clutch to a large diameter pump fly-wheel.

The drilling fluid is often supplied by a water tank truck which feeds the pump and is filled up with clear water.

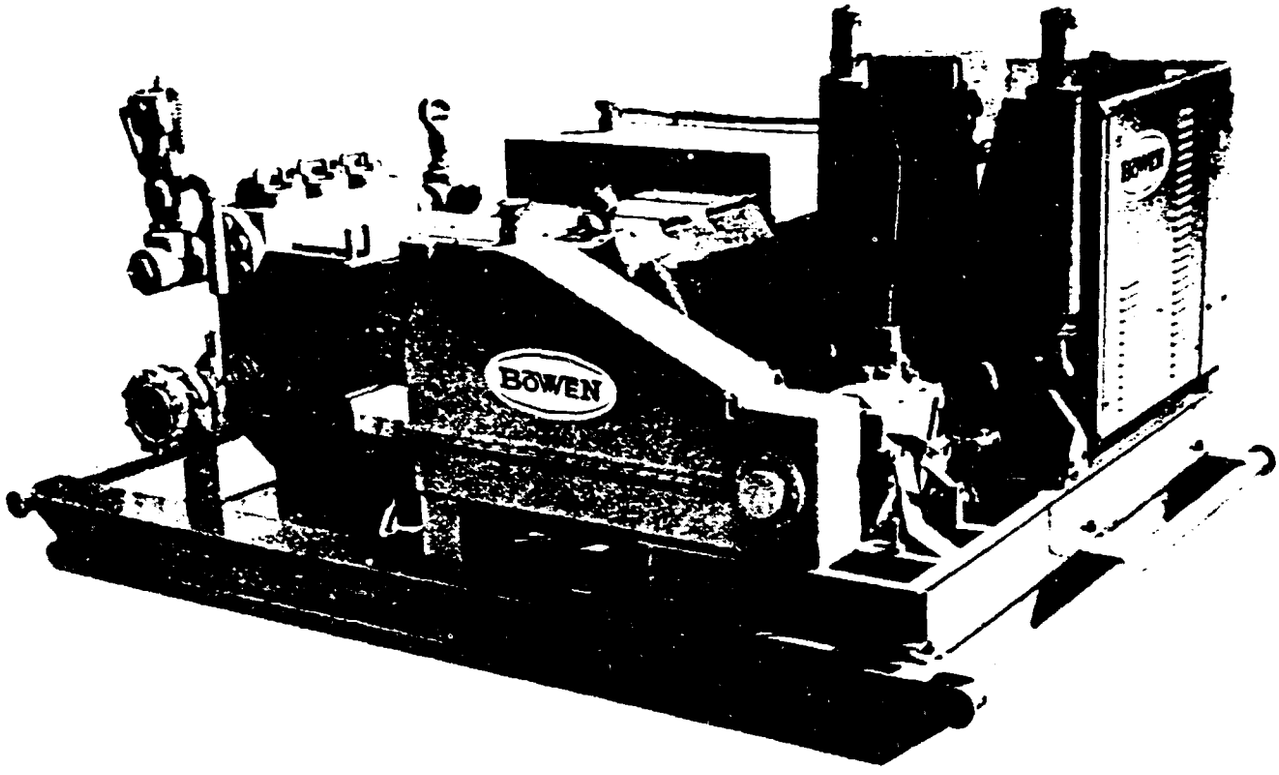


Figure 7. Pump installation on trucks and skid.

5.4.3. The Engines

The power source of a water well drilling rig is normally the truck engine - generally a diesel engine. Power is transmitted from the truck engine through a full torque gear type, split shaft, pressure lubricated power take-off. A chain case distributes the power to the drawworks. The transfer case consists of cast aluminium for lighter weight and heat dissipating qualities. It is oil bath lubricated for longest wear.

The triple or four strand roller chains, designed for high speed use, operate over heat treated allow steel sprockets.

Water well drilling rigs with higher capacities are powered by the truck engine and an additionally installed deck engine. The single power source of the truck engine is sufficient for drilling depths of 1500 to 2000 ft. Engines with BHP 160 to BHP 220 are commonly used.

5.4.4. The Hydraulic System

A common design uses an 18 g.p.m., 2000 p.s.i. variable volume pressure compensating piston pump complete with 40 gallons oil reservoir with filters. The basic hydraulic oil system feeds the pull down, rotary retraction cylinder, mast lift cylinders, hydraulic jacks and the hydraulic break out cylinder. In the case of a power swivel or power sub, the system has to supply these components as well. The hydraulic pumps are the key parts of the system and are given high priority in the maintenance program. Some drilling operations require a higher torque output and power swivels of high capacity are used which necessitates a much more powerful hydraulic system. In this case additional power units are installed.

5.4.5. The Drawworks

Most designs show a main drum (stem drum) and a bailing drum. The main drum is, in some constructions, a double-drum feature for kelly and hoisting lines. The drawworks are equipped with double cam actuated wrap-around mechanical brakes. The bailing drum is powered through a double roller chain drive from the main drawworks shaft and is also operated by a positive engagement spline clutch. The clutches for the stem drum and the bailing drum are in most modern constructions a twin-disc, air-type clutch mounted on a counter shaft. The drawworks are operated with 5-speed forward and one reverse gears. The standard spool capacity of the stem drum ranges up to 1,000 ft. The bailing drum has a capacity to wind up to 3,000 ft. of wire line.

Drive : input-torque tube with "U" joints, right angle gear box H.D. spiral bevel spur type gears. Final 1-1/4" pitch double roller chains on heat treated shafts and sprockets.

DOUBLE DRUM DRAWWORKS

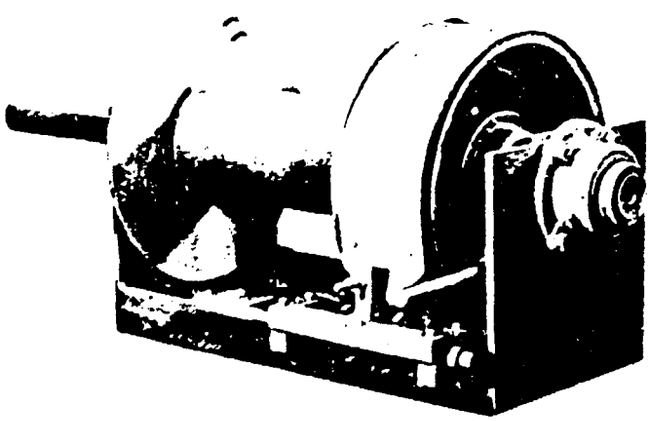


Figure 8.

The design, rating and spool capacity of the drawworks depend on the maximum drilling depth and the weight of drill pipe to be run downhole.

5.4.6. The Power Swivel

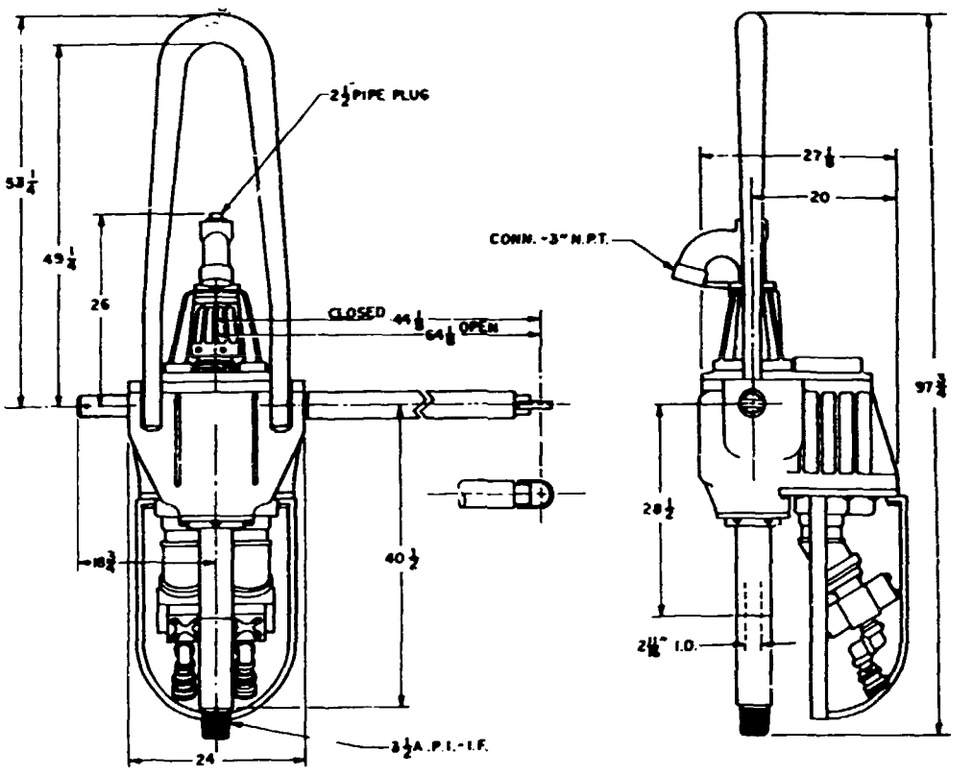


Figure 9. Illustrates the dimensional drawing of a power swivel.

The most important part in many water well drilling rig designs is the power swivel. This component transmits the torque to the drill stem, like a rotary table and provides the main function of a swivel as well, to transport the circulation fluid from the standpipe to the kelly and downhole. The power swivel is specifically designed to replace the conventional drilling swivel, the kelly stem the kelly bushing and rotary table. They certainly have more advantages over the rotary table arrangement. The infinitely variable speed and torque can be more accurately and more safely applied because of the hydraulic power.

Reaming up is possible as well as drilling down since the hydraulic powered swivel can be attached directly to the drill stem. Basically the swivel is a complete system, consisting of a swivel assembly, control assembly and, if required, a prime mover assembly, together with the necessary hoses and connections to connect the three units, and to operate and control them.

The swivel assembly consists primarily of a drive stem, gear train, bearings, hydraulic motors (one or more), washpipe and washpipe packing, gooseneck with straight-thru wire line access, housing and torque rein. The swivel may be fitted with an elevator bail, plain bail, elevator links or a suitable travelling way arrangement (pull down chain device). The washpipe of each swivel is plated and ground smooth, to ensure smooth operation and long life for both the washpipe and the packing around the washpipe. The hydrauiic hose connections to motors are equipped with dust covers.

Common power swivel designs are driven by two piston type hydraulic motors. The two motors are joined by a special manifold assembly which allows both motors to be supplied with hydraulic fluid by only one supply hose, and one return hose. The two motor drains are connected by a simple manifold arrangement formed by a combination of pipe and tubing, immediately outside the motor housings. Both drains meet and feed into a pressure check valve with a drain hose connection at its discharge end. The standard plain bail is forged from a single piece of alloy steel, heat-treated and then finished.

The gear train for this design is composed of two motor drive gears, one reducer drive gear, one intermediate drive gear, and one main gear. The motors are mounted at the bottom, rear of the unit.

The gooseneck with top access opening is made out of cast steel. The design features a braided impregnated packing around a finish ground washpipe. Other important components of the power swivel system are the control assembly which is composed of a ported aluminium block, into which are mounted a directional control valve, a torque control valve, a speed control valve, and four hose connections. The block is mounted on a light but sturdy pedestal. The gauge for read-out is calibrated to indicate torque at the swivel stem in ft.-pounds, and the line pressure in pounds per square inch (p.s.i.)

The control assembly includes the control panel from which the swivel is operated, remote lead-in cables from the control panel to the electric servo-relay system, mounted on the prime mover, and the electric servo-relay system. The control panel is mounted on a light-weight pedestal.

The particular swivel model has to match the power output of the engine assembly. The hydraulic piping assembly includes a direct driven pump, located immediately behind the engine, all piping, valves, filters, fittings and other components required to complete the system.

The hydraulic reservoir has enough capacity to effectively cool the hydraulic fluid. The hydraulic fluid is filtered by both suction and return filters to prevent wear of the hydraulic components. The suction line has a micronic "tell-tale" filter, which indicates by a pointer when it needs cleaning. The return line is filtered by a replaceable cartridge filter.

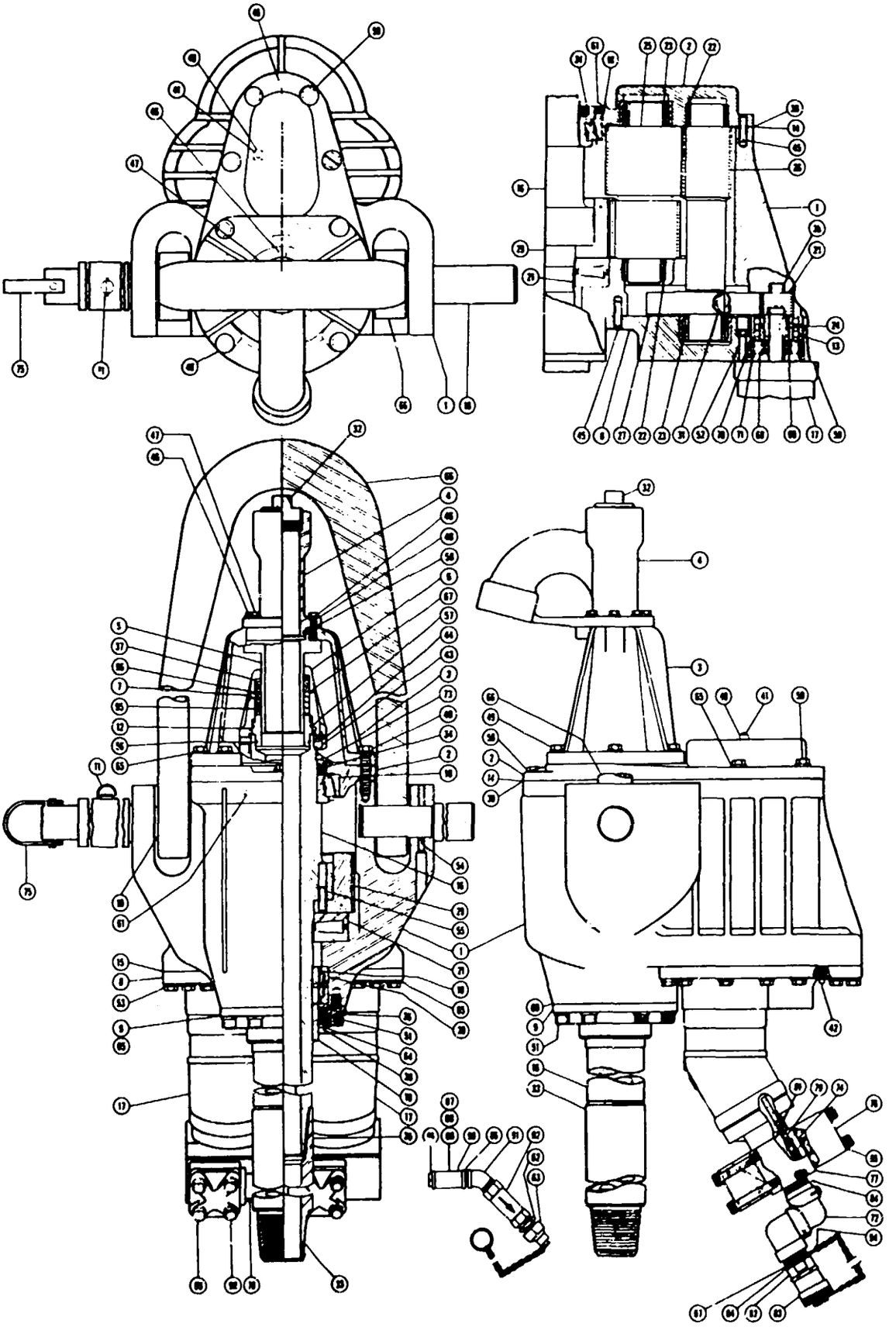


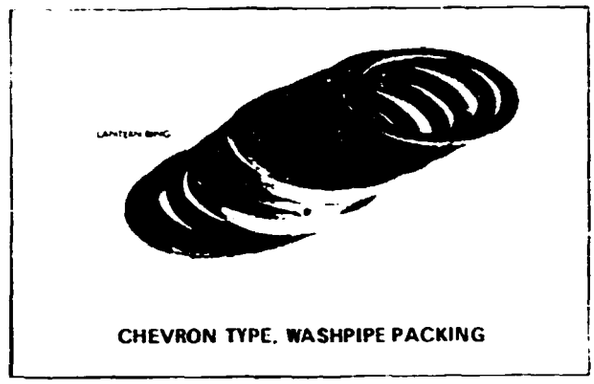
Figure 10.

Item No.	Bowen Part No.	No. Req'd	Part Description	Item No.	Bowen Part No.	No. Req'd	Part Description
1	31495	1	Body	51	27234	6	Low. Brg. Ret. Cap Screw Socket Head
2	27202	1	Upper Cover Plate	52	37641	16	Hyd. Motor Cap Screw Socket Head
3	27203	1	Bonnet	53	27236	15	Gear Cover Cap Screw Hex Head
4	27204	1	Gooseneck	54	31844	2	Bail Pin Groove Pin
5	27205	1	Washpipe	55	27238	6	Ring Gear Groove Pin
6	27206	1	Washpipe Packing Nut	56	5230-20	1	W.P. Junk Ring "O" Ring – Lower
7	27636	2	Packing Nut Grease Fitting	57	6230-24	1	W.P. Junk Ring "O" Ring – Upper
8	27207	1	Lower Gear Cover Plate	58	6227-42	1	Gooseneck "O" Ring
9	27228	1	Lower Stem Bearing Retainer	59	26580	2	Hydraulic Motor Gasket
10	31482	2	Bail Pin	60	27239	1	Lower Stem Brg. Ret. Gasket
11	51413	1	Torque Rein Pull Pin	61	28189	3	Pipe Plug
12	27213	1	W.P. Packing Nut Junk Ring	62	56548	1	3/4" Coupling - Nipple Half
13	22340	2	Motor Drive Gear Brg. – Lower	63	25113	1	Dust Cap – 3/4"
14	27275	1	Upper Gear Cover Gasket	64	30362	1	Seal Retainer Ring
15	27276	1	Lower Gear Cover Gasket	65	29190	32	Lockwashers – 3/4"
16	44164	1	Stem	66	31206	1	Plain Bail
17	20482	2	Hydraulic Motor	67	27273	1-Set	Washpipe Packing – Braided Type
18	27277	1	Upper Stem Bearing	68	47080	2	Motor Seal Plate
19	27278	2	Lower Stem Bearing – Inner	69	43249	4	Motor Seals
20	27426	1	Lower Stem Bearing – Outer	70	6230-21	2	"O" Ring Seals – Motor Seal Plate
21	27279	1	Main Thrust Bearing	71	31072	8	Button Socket Head Cap Screws
22	27280	2	Intermediate & Red. Gear Bearing	72	31959	2	1-1/2" Pipe Swivel Joint
23	27281	2	Intermediate & Red. Gear Bearing	73	44165	1	Seal Protector
24	20739	2	Drive Gear Key	74	568-325	4	O-Ring (Replacement)
25	27209	1	Intermediate Gear	75	30384	1	Torque Rein
26	27211	1	Reducer Drive Gear	76	30906	4	Manifold Flange
27	27212	1	Reduction Driven Gear	77	30572	2	Manifold Block
28	27626	2	Motor Drive Gear	78	31925	2	Cross-Over Tube
29	27208	1	Main Drive Gear	79	31924	8	Socket Head Cap Screw
30	22342	2	Motor Drive Gear Bearing – Upper	80	23907	8	Socket Head Cap Screw
31	39873	1	Reduction Gear Key	81	6230-3	4	"O" Ring Seals – Manifold
32	27283	1	Gooseneck Plug	82	38079	2	1-1/2" Coupling - Nipple Half
33	27284	1	Saver Sub	83	38080	2	Dust Cap – 1-1/2"
34	27285	1	Upper Oil Seal	84	27514	4	Close Nipple – 1-1/2
35				85	31828	16	Lock Washer – 5/8" Spring Type
36	27286	1	Lower Oil Seal – Inner	86	35768	3	Close Nipple – 3/4"
37	27255	1	Upper Packing Ring	87	22362	1	90° Ell – 3/4" (Not Shown)
38	27416	1	Lower Oil Seal – Outer	88	35769	2	Tubing Connector (Not Shown)
39	27287	1-Set	Upper Gear Cover Shim	89	30005	1	Tubing – 3/4" (Not Shown)
40	25389	1	Oil Filler Plug	90	27432	1	Tee – 3/4"
41	22177	1	Relief Fitting	91	35770	1	45° Street Ell
42	20627	1	Magnetic Drain Plug	92	35771	1	Check Valve – 3/4"
43	29518	1	W.P. Packing Nut Key	93	44055	A/R	Thread Sealant
44	6460	1	W.P. Packing Nut Screw – Socket Head	94	35245	2	"S" Hook
45	27289	2	Cover Dowel Pin				OPTIONAL
46	27230	3	Gooseneck Cap Screw Hex Head	95	27804	1	Washpipe Packing – "V" Type
47	27231	4	Washpipe Cap Screw Hex Head	96	27834	1	Lantern Ring
48	31827	7	Lock Washers – 1/2" Spring Type	97	39227	2	Chain Retainer
49	27232	6	Bonnet Cap Screw Hex Head	98	23908	8	Socket Head Cap Screw
50	27233	5	Top Cover Cap Screw Hex Head	99	56957	1	Seal Plate Gasket

Figure 10. Shows the section of a power swivel and the list of spare parts belonging to it.

The operation pedestal is covered by a non-skid floor.

The washpipe packings are teflon impregnated asbestos. The use of Chevron-type packing is another option. This packing requires the use of a lantern ring.



CHEVRON TYPE, WASHPIPE PACKING

Figure 11.

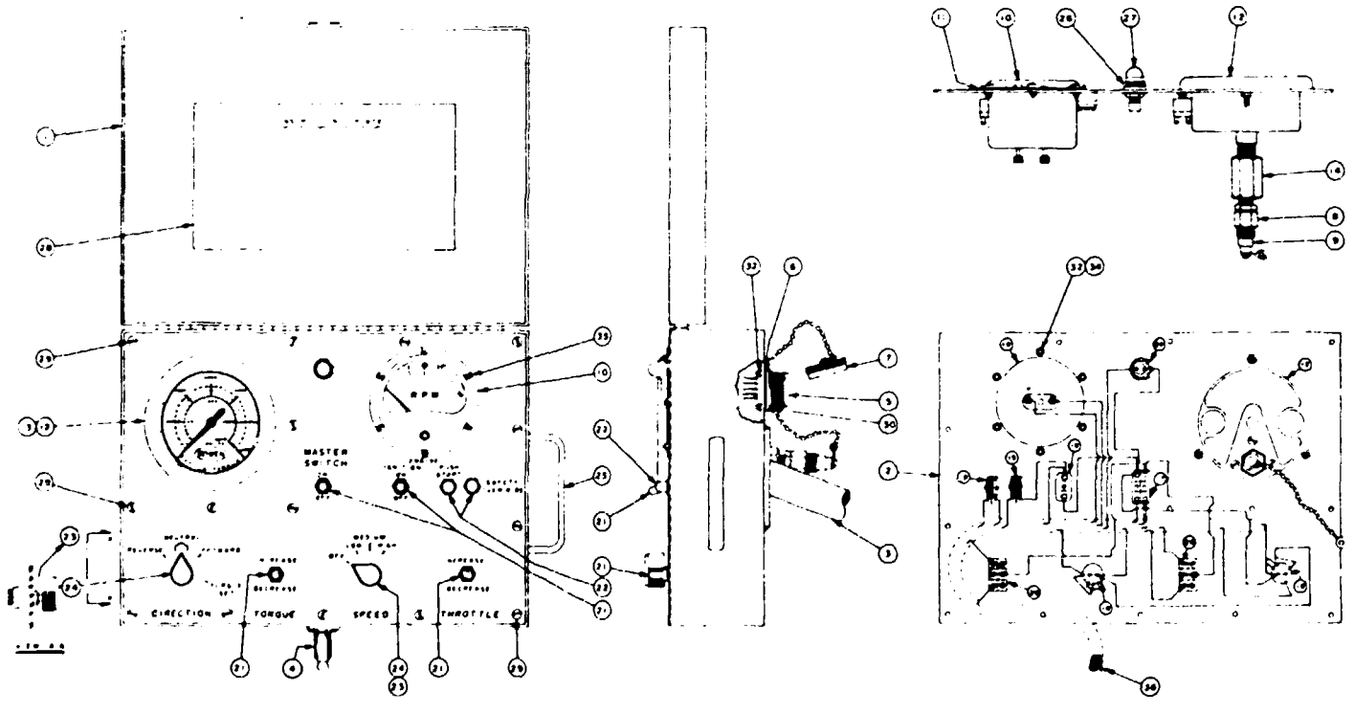


Figure 12. Shows a power swivel control panel sub-assembly. (with description list over page).

Item No.	Bowen Part No.	No. Req'd	Part Description	Item No.	Bowen Part No.	No. Req'd	Part Description
1	28673	1	Cabinet	19	28855	1	Safety Override Switch
2	30364	1	Panel	20	28435	2	Throttle & Torque Switch
3	28674	1	Cabinet Stand	21	28432	4	Switch Seal
4	50144	1	Cabinet Latch	22	28434	2	Push Button Boot
5	28675	1	Electrical Connector	23	28854	2	Switch Shaft Seal
6	50272	1	Gasket	24	28853	2	Switch Knob
7	28676	1	Dust Cap	25	27104	1	Handle
8	29481	1	Self Sealing Coupling	26	28680	1	Red Light
9	27589	1	Dust Cap	27	28681	1	Bulb
10	30515	1	Tach. Head	28	20736	1	Instruction Plate
11	50446	1	Tach. Gasket	29	28856	17	Seal Screws #10
12	22851	1	Torque Gage	30	28857	4	Seal Screws #6
13	41200	1	Gage Face	31			
14	37303	1	Torque Gage Coupling	32	27122	10	Nuts
15	28433	1	Starter Switch	33			
16	28431	1	Ignition Switch	34	37155	6	Brass Flatwasher F/#6 Scr.
17	28849	1	Master Switch	35	37156	6	Seal Screw #6
18	28677	2	Direction & Speed Control Sw.	36	27109	75	Electrical Wire

5.4.7. The Power Sub

Another commonly employed drive in water well drilling operations is the power sub. The sub is powered hydraulically like the power swivel.

The power sub has the basic features of a power swivel and its functions are the same. The subs are composed essentially of a body, hydraulic drive motors, appropriate stem, gears, bearing and closures as required to transmit the power from the prime mover to the drill stem. Torque back-up is provided for by a simple torque arm receptacle. An appropriate telescoping torque rein is furnished with each sub. The difference to the power swivel with regard to drilling operations is that the power sub requires an extra conventional drilling swivel. Naturally a source of hydraulic power and the proper size and type of hydraulic hoses and connections are needed. Saver subs are screwed to up and down connections.

The hydraulic power system has been explained previously in the discussion of the power swivel.

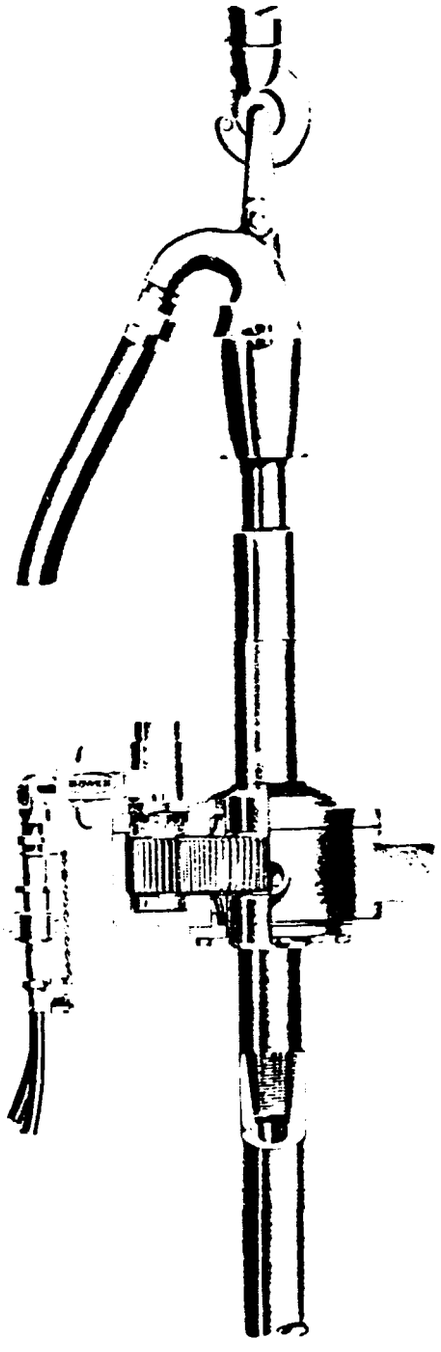
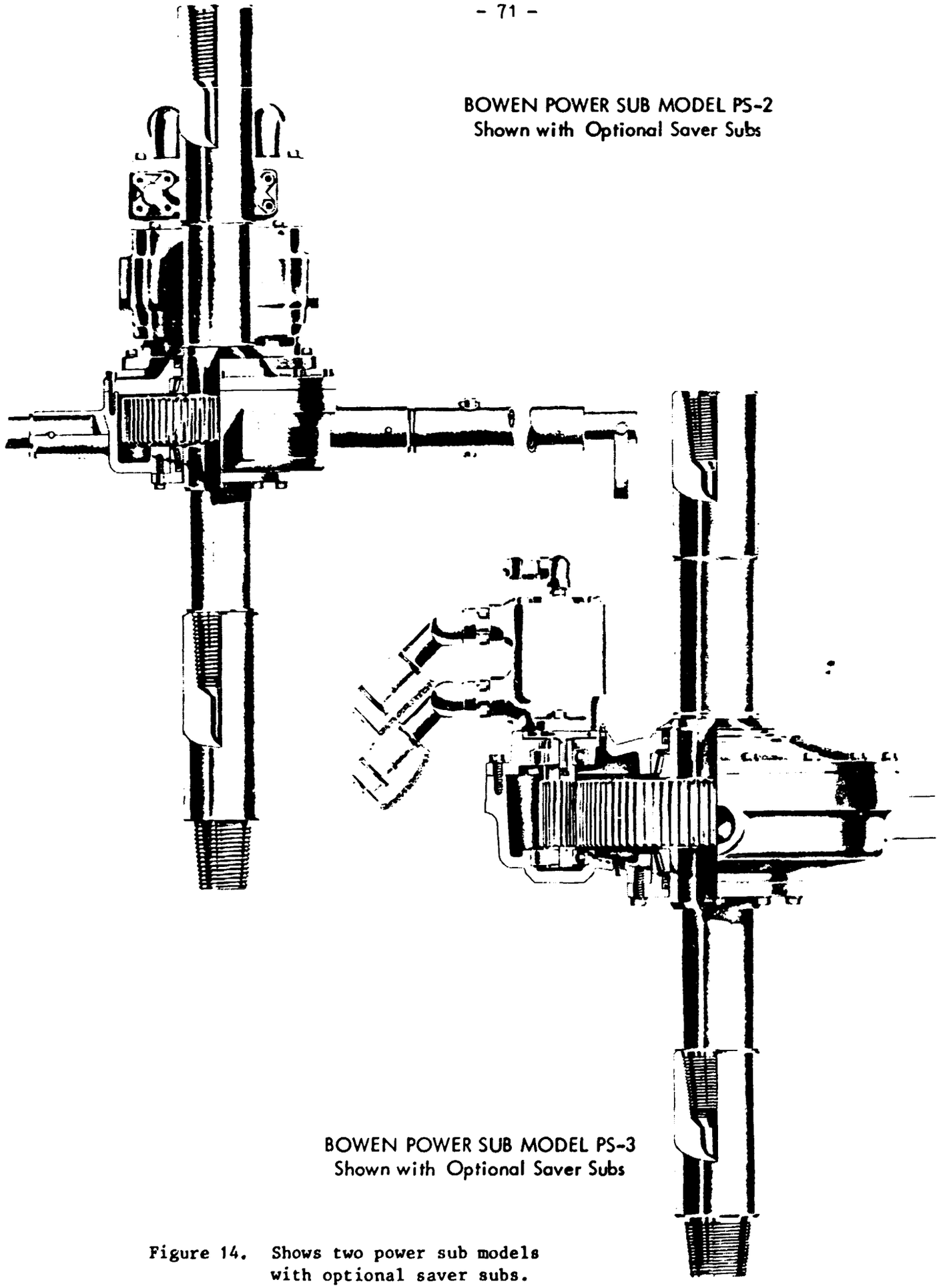


Figure 13. Illustrates a power sub in working position.

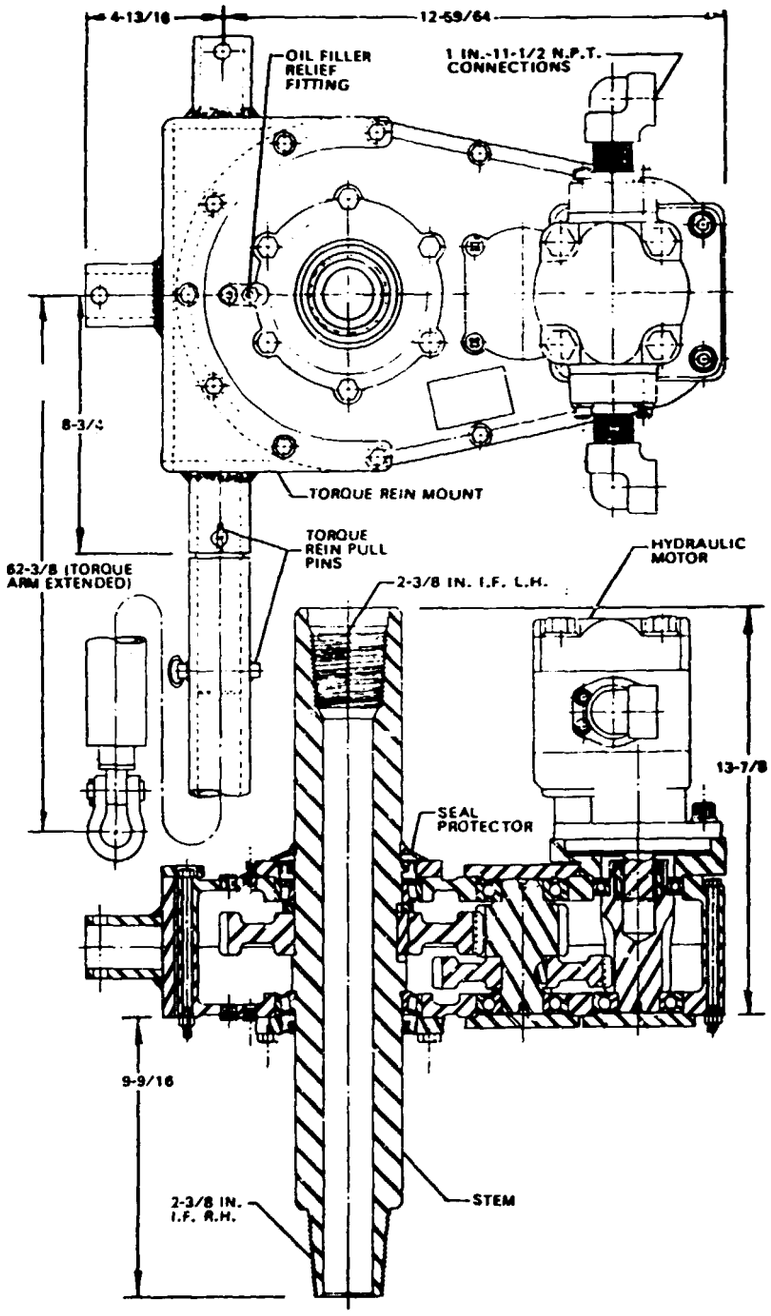


BOWEN POWER SUB MODEL PS-2
Shown with Optional Saver Subs

BOWEN POWER SUB MODEL PS-3
Shown with Optional Saver Subs

Figure 14. Shows two power sub models with optional saver subs.

Selecting the power sub model depends on the existing hydraulic power system. In order to achieve the maximum performance of the sub the power requirements should match the engine assembly capacity.



BOWEN PS-45 POWER SUB AND PRIME MOVER SPECIFICATIONS

POWER SUB		
Complete Assembly	Part No. Weight	72438 300
Max. HP Rating		45
Hyd. Motor		Gear Type - Internally Drained
Max. Torque at 2000 PSI Hyd. Fluid Pressure		1485 ft./lbs.
Max. Tensile Load		313,000 lbs.
Stem Connections	Upper Lower	2-3/8" IF. LH Box 2-3/8" IF. RH Pin
Hyd. Motor Connections		1" NPT SAE 4-Bolt Flanges with 1" Elbow
Water Course Through Stem ID		1-3/4" Dia.
4-Way Control Valve (Optional for use with rig prime mover)	Part No. Weight Rating	63909 50 lbs. 45 GPM at 2000 PSI
PRIME MOVER		
Complete Assembly Skid Mounted	Part No. Weight	74132 4800
Complete Assembly Trailer Mounted	Part No. Weight	74133 5100
Power Plant		58 HP, GM 3-53 Diesel
Fuel Tank Capacity		40 Gals.
Hydraulic Fluid Reservoir Capacity		125 Gals.
Hyd. Pump		45 GPM Gear Type
Controls: Pedestal Mounted with Torque/Pressure Gage	Direction Torque	Manual Valve Manual Wheel
Supply Hose (High Pressure)		1" x 50' 2500 PSI
Return Hose (Low Pressure)		1" x 50'
Hose Couplings		Quick Disconnect Self Sealing

Figure 15. Shows the vertical section of a power sub displaying all the details.

5.4.8. The Rotary Table

Some rig designs use the rotary table to transmit torque to the drill stem. The rotary tables are of course of smaller construction compared to the oil rig rotaries but retain the same features as discussed in the brochure about drilling rigs for oil and gas exploration.

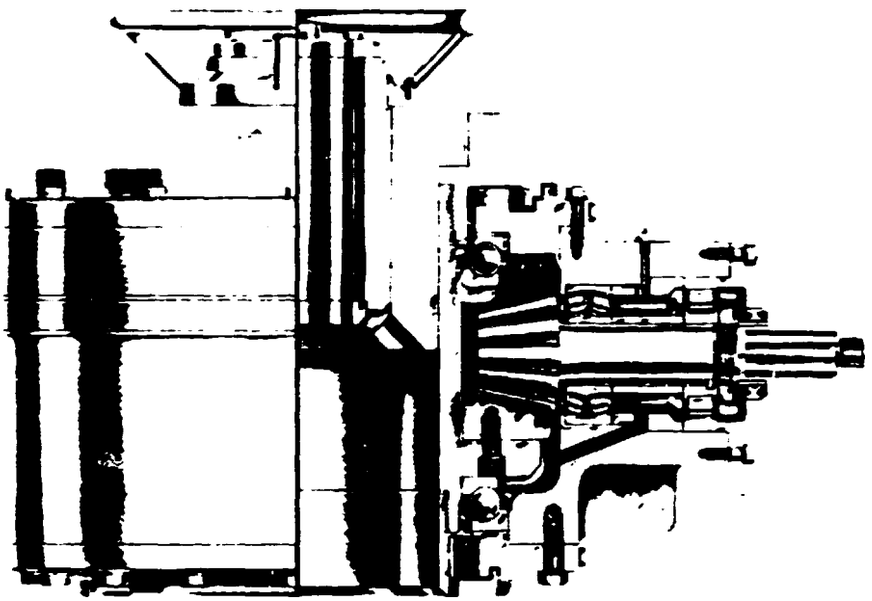


Figure 16. Shows an example of a rotary table used by a water well drilling rig.

The rotaries above feature enclosed oil bath lubrication. They are hydraulically retractable for handling casing and tools and can be powered through 5-speed mechanical transmission plus reverse. Speed range is 25 to 250 r.p.m. They have square or hexagonal openings.

In some designs the drive assembly is composed of a hypoid cut ring gear and pinion with a 6:1 or 5:1 ratio and tapered roller bearings. The clutch may be a twin-disc friction type.

5.4.9. The Mud System Units

The mud system units correspond to the units of an oil and gas drilling rig, but show a much simpler design and consist only of basic components. The mud pits are normally dug out of the ground. Water supply is carried out by water tank trucks. The suction hose or piping of the mud pump charges the pump with drilling fluid out of the earth pit through a filter only. The drilling fluid is not exposed to any particular cleaning process and a steel suction tank is normally not required.

One or two tanks with simple mixing facilities and the necessary flow lines make up the mud system in most cases. Sometimes a shale-shaker is employed.

5.4.10. The Control Stand

The controls are normally grouped at operator's position on the left hand of the rear of drill frame - such as air clutch and throttle controls with optional manual controls; manual brake levers with extra long handles for greater leverage; and hydraulic control valves.

A typical example of a control stand looks like the following :-

Instrument Panel :

- Engine tachometer, starter switch and engine gauges.
- Rig gauges.
- Rig lights switch.

Driller's Station Controls :

- Drawworks controls.
- Rotary Table controls.
- Mast lift control.
- Table retraction.
- Right, left and front jack controls.
- Pull-down controls.
- Air operated engine throttle.
- Fluid line dump valve.
- Oil field type mud line pressure gauge.

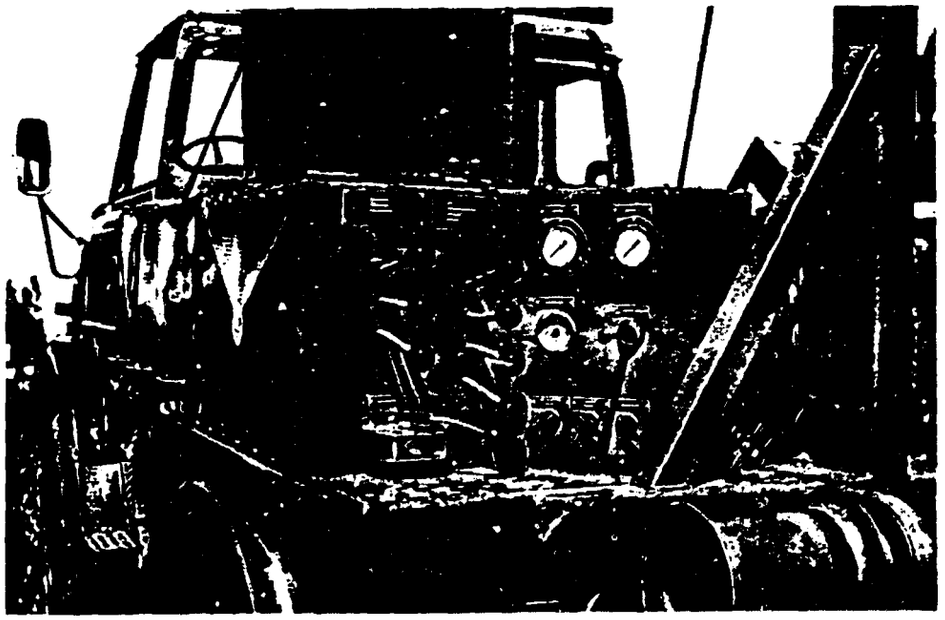


Figure 17. Shows an example of an instrument panel.

5.4.11. Miscellaneous

The air compressor is another important component of a water well drilling rig. It is mounted on the truck like the other power units and is used for instance for air flush, down-the-hole hammer drilling and other functions of the rig. Some designs have a two-stage high pressure rotary screw compressor. Rigs with smaller capacity are furnished with single stage compressors.

The air compressor is driven by V-belt from the main drive. Normally the air compressor is installed immediately behind the driver cab.

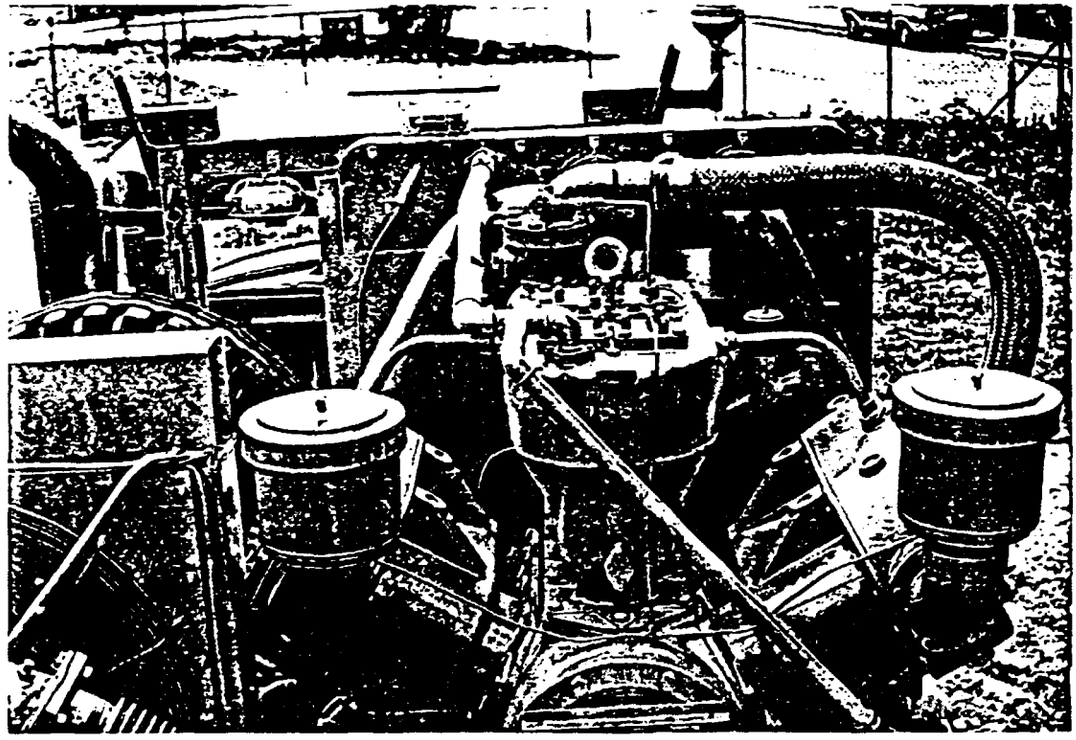


Figure 18. Air compressor arrangement.

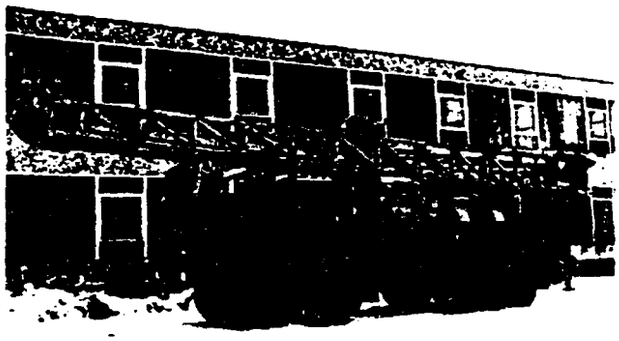
The frame where power units, pumps and drives are mounted is designed as a heavy duty structural steel frame, electrically welded and covered with non-slip deck plates and with guards over all moving parts. Furthermore, the frame is equipped with a mast rest, stem box and clearance lights and reflectors.

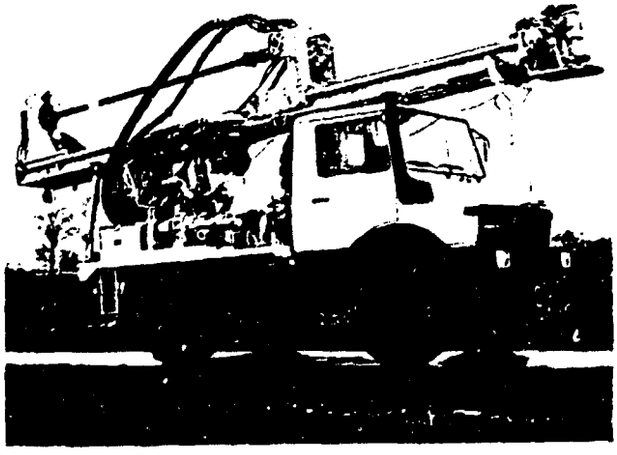
Standard mounting is on a tandem rear axle truck or carrier in most designs, with a specified minimum GVW rating. The cab to tandem centre line dimension and the engine horse power depend on the respective mud pump and air compressor selection.

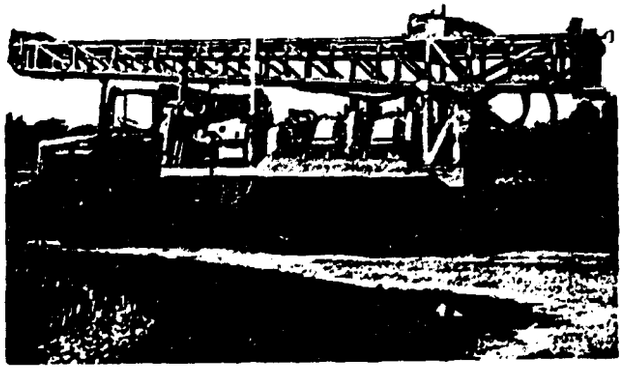
Some drilling operations require a skid or tandem axle semi-trailer mounting with a power unit available. As an example, a water well drilling rig of the more heavy-duty categories (casing load up to 100,000 lbs.) shows the following specifications of mounting :

On 40' (12.1m) single drop, tandem axle trailer. Axle rated at 20,000 lbs. each. Dual 11:00 x 20 tires. Main beams are 18" x 35 lbs., "S" beam with 16" x 26 lbs., "W" beam on cross member. A third axle is optional.

Figure 19. shows different types of truck and/or carriers commonly used.







Optional equipment for a water well drilling site might be the following:-

Hydraulic levelling jacks, auxiliary fuel tanks, a water injection system, an air line lubricator, dust deflector, lighting plant, welding generator, racking boards, break out or drill pipe slips, additional slow speed rotary table drive for down-hole hammer drilling, catheads, optional engines and carrier mounted. Further - tool box, air foot throttle, tongs for drill pipe and rig maintenance tools.

Modern truck mounted water well rigs are furnished with standard operating equipment from the outset, which includes :

A 5/8" or 3/4" non-rotating cable, kelly and stem drums, kelly to swivel and kelly to drill pipe adaptors, a screw type swivel hoist plug, kelly drive bushing, break out or drill pipe slips, 2" or 3" ID stand pipe and discharge hoses, travelling block, driller's platforms, tool box, stem box, generator, three lights and break out tongs with counterweights.

5.5. Water Well Drilling Rigs - Detailed Comments on different sizes, types and equipment

The up to date, most important demands on the design of a water well drilling rig are :

a) The operation of the rig is fully hydraulic. The various available drives can be adjusted infinitely from the driller's control stand with regard to speed or number of revolutions.

b) The easy mobility of the rig, especially under severe conditions of the geographical area encountered.

These two design features contribute mainly to the economical feasibility of different drilling operations. Manufacturers and designers have to direct their attention to a large extent on the automation of different rig operations in order to provide for an efficient and economical performance. The recent, on the market, available designs meet these requirements in many respects and the technical evolution of the last 10-15 years has generated a great deal of improvements.

5.5.1. Cable Tools

The first type of drilling which came into general use was the percussion or cable-tool method. A metal chisel was attached below a column of rods which were raised and dropped while being slowly rotated by hand tillers to produce a circular hole. Rope was sometimes used instead of rods and this eventually became standard practice.

In the cable-tool or percussion drilling technique a string of tools is suspended on a steel wire rope which is passed over a rubber-cushioned crown sheave at the top of the drill rig and down under a spudding sheave at the end of a beam.

It then passes up and over a heal sheave at the fulcrum end of the beam. The rope finally leaves the heal sheave to coil in storage on a braked drum known as the bull reel or main reel. A connecting rod transmits motion from a variable stroke crank to the free end of the beam which itself imparts a reciprocating action to the rope and suspended tools.

The drilling line is of non-preformed, left hand lay, steel wire rope. The sand line made of the same material is used for the bailer to clean the borehole.

Cable-tool rigs are now equipped with portable electric welding plant to be used for different purposes - (bit sharpening and reforming, hard build-up, etc.)

To sum up, the cable rigs, compared to rotary rigs, by their rugged simplicity, have a longer life, are less specialized and sales are accordingly lower. Their efficiency, of course, is very limited.

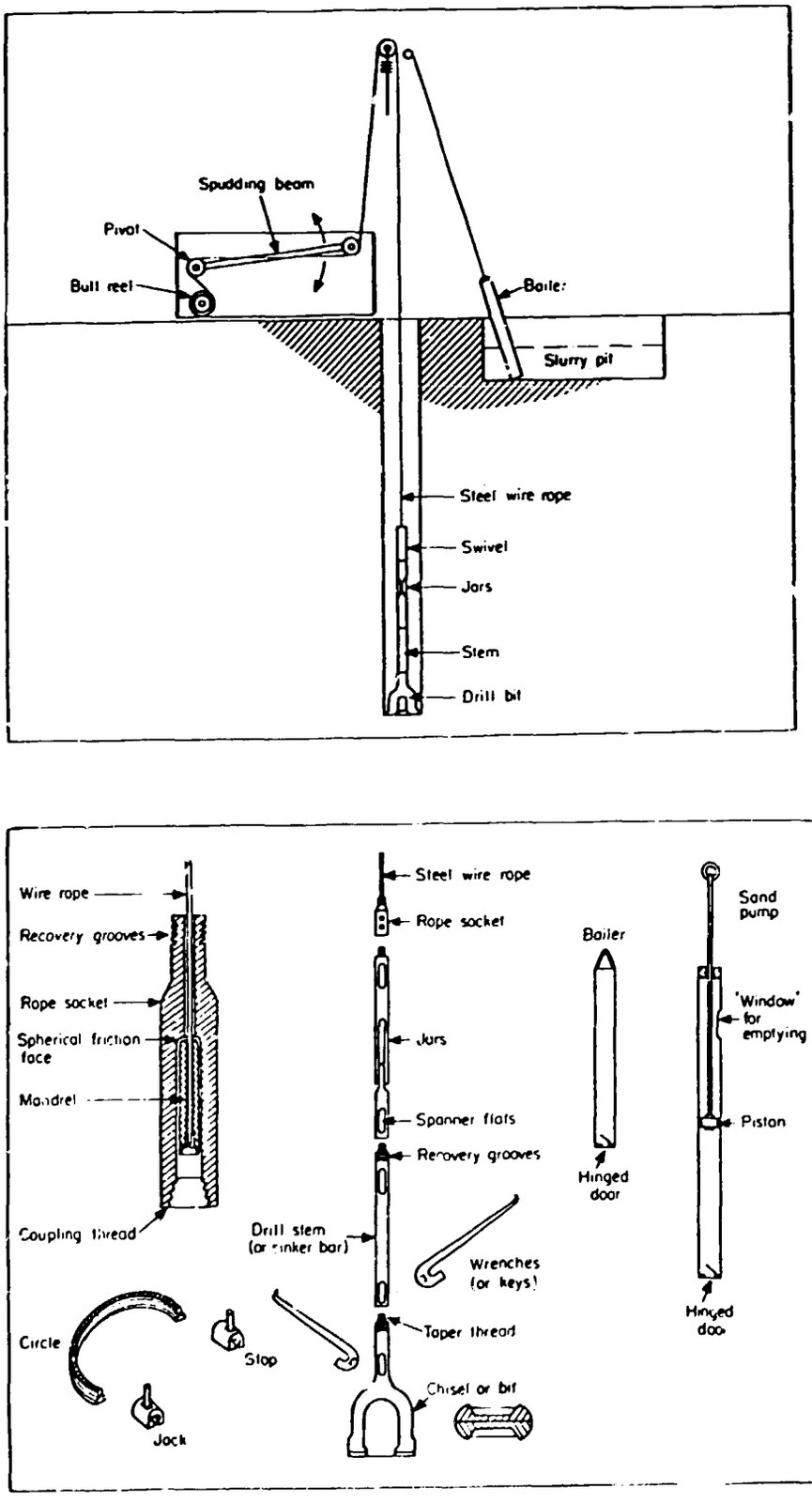


Figure 20. Shows a principle sketch of a cable-tool rig.

The most basic and simple cable-tool consists of a tripod, using wooden or steel beams, one or two top pulleys and two sheaves on the ground surface. A diesel engine is used to operate the rig.

Figure 21. Illustrates modern design cable tool rigs.

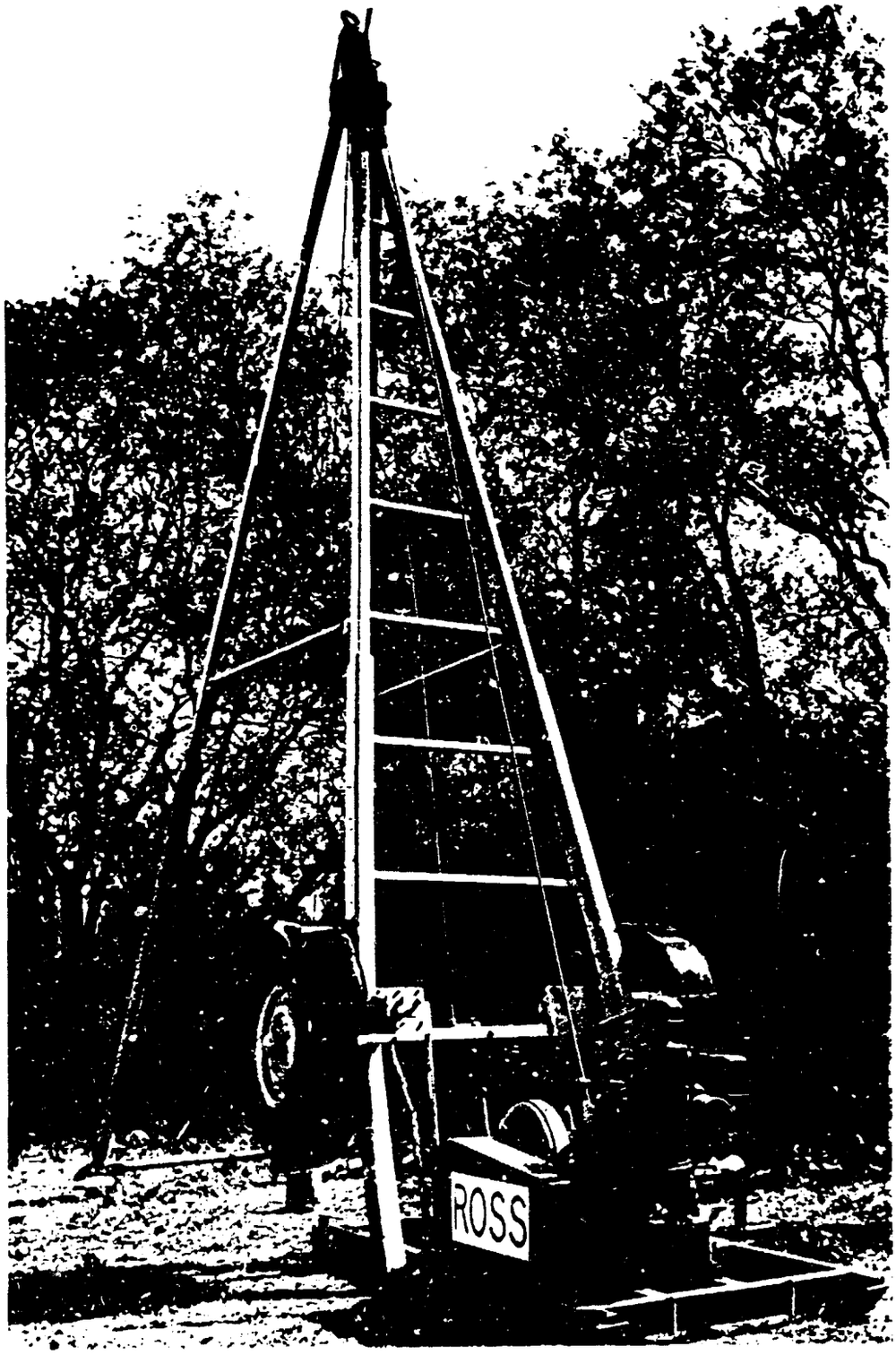


Figure 22.

The first picture shows a rig which can be transported as a trailer by a light truck of the Landrover type. The trailer is fitted with overrun brakes. The equipment has hydraulic take-offs for auxiliary tools. The chassis and legs are raised by the winch. The winch is a mechanical-hydraulic driven winch with a mechanical hand brake. A disk coupling is used as impact machine. The air cooled diesel engine has an electrical starting facility. It produces 20 h.p. at 2000 r.p.m.

The second picture shows another design of a cable tool rig where again the drill frame and mast are of robust construction, manufactured in rolled hollow square steel section electrically welded and braced to withstand all drilling and travelling stresses, with the minimum weight to strength ratio.

A ratchet, built in the winch drum and activated externally provides ease of operation for suspended loads. The punching operation is controlled by external band brakes which can be replaced in several minutes where excessive wear takes place. Capacities range from 2500 lbs. to 10000 lbs. Depth rates : 450 to 700 ft. including a wide range of bore hole sizes. The engine is again an air cooled diesel engine with 30 h.p. at 2200 r.p.m.

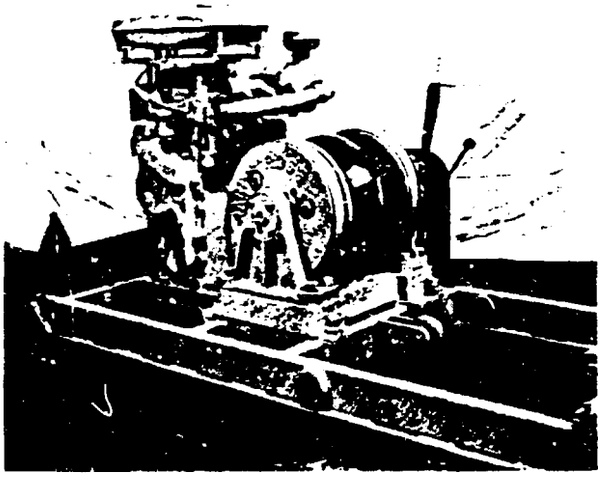
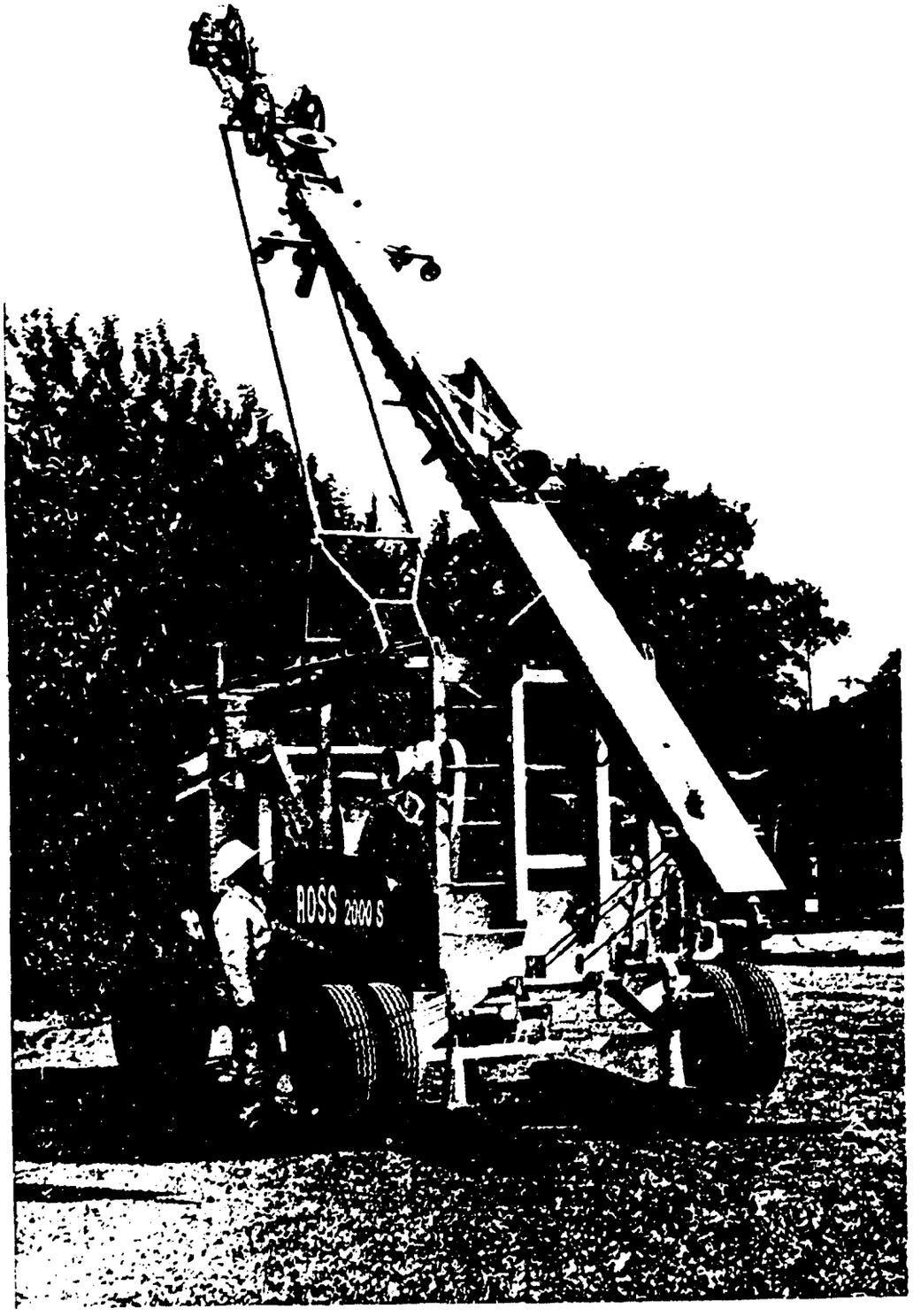


Figure 23. A typical diesel engine used for cable-tool drilling operations.

The winch incorporates epicyclic gear train having heavy duty alloy steel gears, thereby avoiding the necessity for a friction clutch. Either large area phosphor bronze bushings, or needle roller bearings are fitted. The winch drum is controlled by two band brakes, one for hoist operation and one for drum braking. The winch incorporates an externally operated ratchet for permanent load suspension. It will be automatically released on activation of hoist lever. A throttle control is at driller's position. As explained, the external brake bands on the winch unit can be adjusted or changed in a matter of minutes. Grease nipples are provided for regular greasing of drum bearings. The reduction gear box is lubricated by an oil bath. The unit is mounted on a pneumatic tyred axle.

Some cable-tool rigs employ a telescopic pole type mast. Figure 24. illustrates this type of mast.



The rig pictured in this figure has the capacity to drill to a maximum of 2000 ft. providing a wide range of bore hole sizes. Sheaves are mounted in either roller bearings or bronze bushings.

The following specifications are given by the manufacturer:

Trailer : robust running gear with swivelling forecarriage and stowage brake.

Truck : 4 x 4 or 6 x 4 cross country vehicle min. 16 ton GVW.

Power Unit : Air cooled diesel engine - developing 60 b.h.p. at 2000 r.p.m. (one hour rating) equipped with electric start - 20 gallon (91 litre) fuel tank - heavy duty air cleaner - variable speed control located at operators' position.

Gearbox : providing high normal and low speeds to all drums and spudder with reverse drive in all ratios - direct mounted on power unit having clutch and reverse selections remote controlled from operator's position.

Mast : Telescopic pole type 48 ft. from centre line crown sheave to ground level closed length 34' - 9" - power operated raising and lowering - capacity 45,000 lbs. - fitted with 8 point self erecting braces and foot jack.

Mast Elevating Gear : power operated - self sustaining worm driven drum - controlled through 5" single plate clutch.

Shock Absorber : Unitised drill line sheave assembly mounted on rubber shock absorber.

Sheaves :
- drill line : roller bearing - 20" dia.
- sand line : roller bearing - 14" dia.
- casing line : roller bearing - 18" dia.
- heel shaft : bronze bushed - 18" dia.
- spudder : bronze bushed - 16" dia.

Jackshaft : Large diameter - carried in heavy duty self aligning spherical roller bearings - driven from power unit by multi V-belts.

Bull Reel : gear driven from jackshaft :
- spooling capacity : 3/4" drill line - 2600 ft.
- clutch : 3 plate 11"
- barrel : 10-3/4" dia. x 38" long.
- brake : hydraulic dual caliper - 36" disc.

Casing Reel : gear driven from jackshaft :
- spooling capacity : 430 ft. - 3/4" dia. line.
- clutch : 3 plate 11"
- barrel : 7" dia. x 12-1/4" long.
- brake : hydraulic - dual caliper - 34" disc.

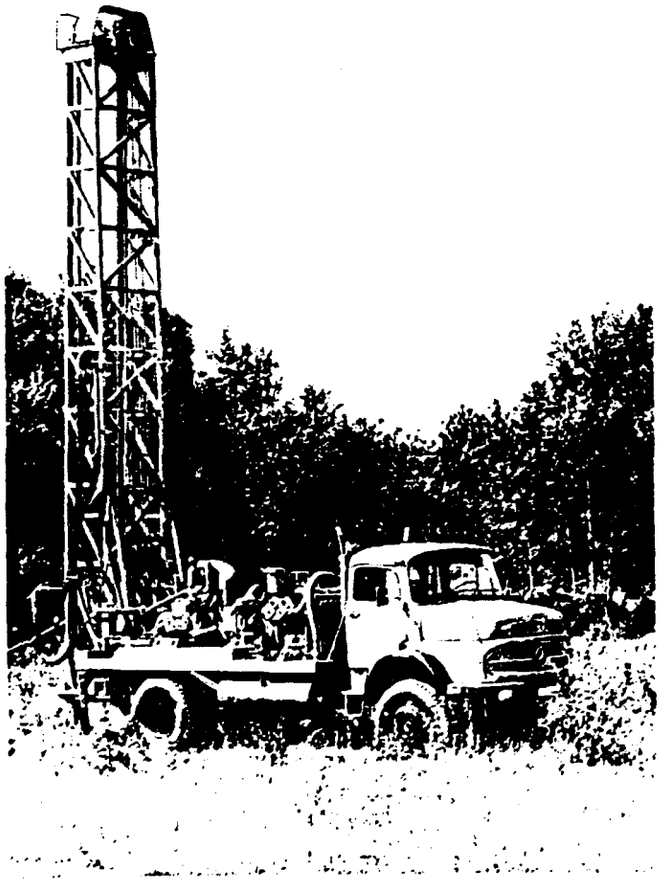
Sand Reel : chain driven from jackshaft :
- spooling capacity : 2900 ft. - 7/16" dia. line.
- clutch : 2 plate 11".
- barrel : 6-5/8" dia. x 13-5/8" long.
- brake : hydraulic - dual caliper - 34" disc.

Spudder : balanced gear drive from jackshaft by heavy duty Pitman fitted with bronze bearings :
- clutch : 3 plate 11"

5.5.2. Truck Mounted Water Well Drilling Rigs

There are many different sizes and types of rigs on the market. Most of them feature the equipment and capacities to meet up-to-date requirements of different drilling operations. The tendency in designs is more inclined to the fully hydraulic powered rig. All functions and operations on the rig are supposed to be controlled by hydraulic power; although it has to be conceded that in some areas the rotary table is given preference over hydraulic drives. This depends mainly on the geological formations and power output available.

Figure 25 shows different types of modern water well drilling rigs using either one of transmission of torque.



folding mast

height:	36 ft.
crown load:	35.200 lb.
table opening:	27 1/2"
working clearance:	22' 11 1/2"

feeding-chain pulldown

1 st gear – hoist capacity:	26.440 lb.
operating speed:	up to 43' 3 1/2 " /min
2nd gear – hoist capacity:	11,000 lb.
operating speed:	up to 98' 4 5/8" /min
3rd gear – hoist capacity:	4.400 lb.
operating speed:	up to 197 ft.

power swivel

torque:	650 da Nm
speed:	0-120 rpm
opening:	5 1/8 "

mud pumps

1 duplex piston pump	5 x 6 "
discharge:	167 Imp. gal.
working pressure:	319 psi.
2 centrifugal pumps	
discharge:	up to 2 x 220 Imp. gal.
working pressure:	up to 140 psi.

compressor

discharge:	220 cu. ft.
working pressure:	127 psi.

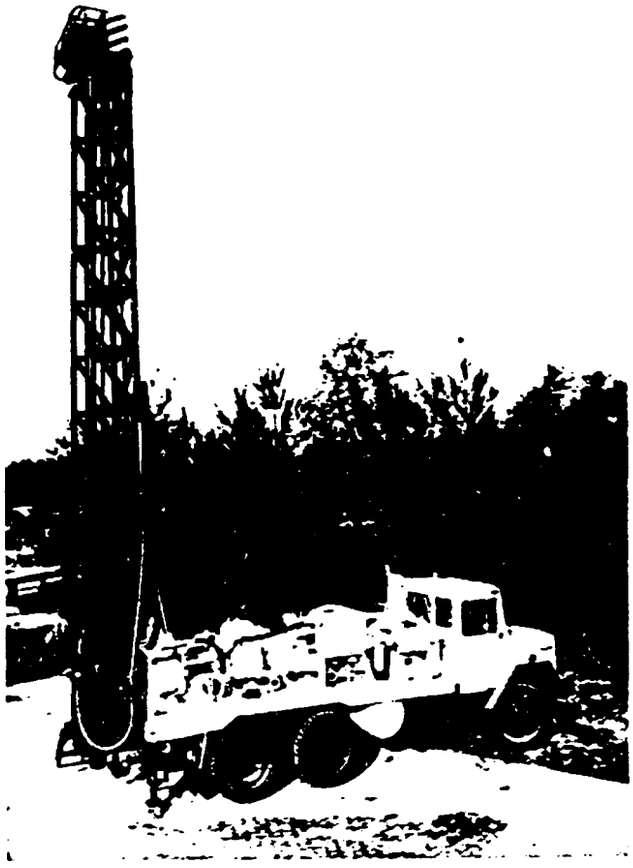
hoisting drum

line pull:	11 000 lb.
line capacity:	850 ft. - 9/16 " ϕ

hydraulic slip device

hydraulic slips, max. opening: 9 7/8"

Figure 25 (a) Fully hydraulic mobile drilling rig.



folding mast
height: 36 ft.

crown load: 66100 lb.
table opening: 27 1/2 "
working clearance: 22' 11 1/2 "

feeding-chain pulldown
1 st gear – hoist capacity: 40100 lb.
operating speed: up to 43' 3 1/2 " /min
2nd gear – hoist capacity: 16750 lb.
operating speed: up to 98' 4 5/8 " /min
3rd gear – hoist capacity: 7500 lb.
operating speed: up to 197 ft./min

power swivel
1 st gear – torque: 1000 da Nm
speed: 0–60 rpm
2nd gear – torque: 470 da Nm
speed: 0–125 rpm
opening: 5 7/8 "

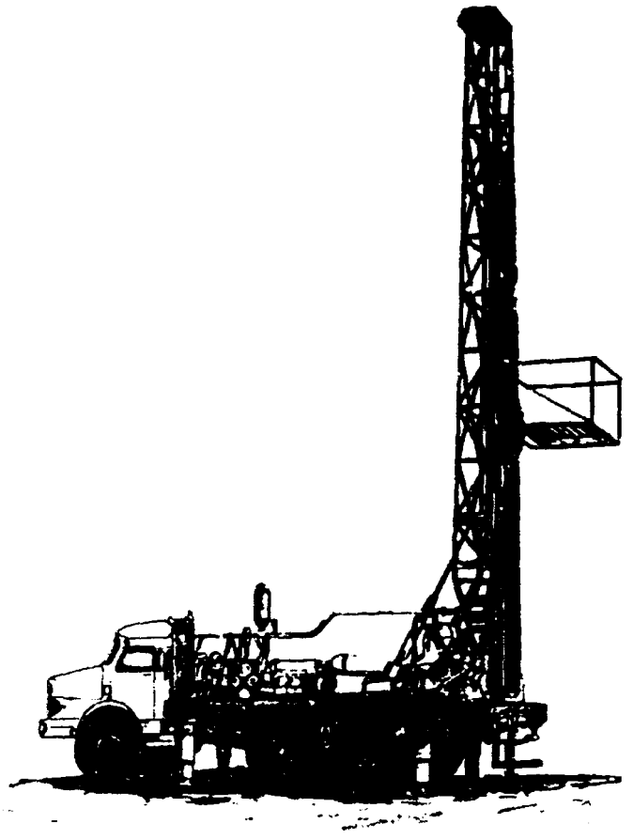
mud pumps
2 duplex piston pumps 5 x 6 "
discharge: 2 x 167 Imp. gal.
working pressure: 320 psi.

compressor
discharge: 335 cu.ft.
working pressure: 255 psi.

hoisting drum
line pull: 11000 lb.
line capacity: 850 ft. – 9/16 " ϕ

hydraulic slip device
hydraulic slips, max. opening: 12 5/8 "

Figure 25(b). Fully hydraulic mobile drilling rig.



for circulation drilling

Technical data:

folding mast:

height	11 m (35 ft.)
crown capacity	20 Mp

rotary table

mechanically driven

speed	21 - 160 rpm
bearing load at 100 rpm	62.000 lbs

opening 8 $^{1}/_{2}$"

hydraulically retractable to provide 18" square opening

draw works:

double drum

spooling capacity	2 x 500 ft. - $^{5}/_{8}$" ϕ
single line pull	30.000 lbs
speed (bare drum)	214 fpm

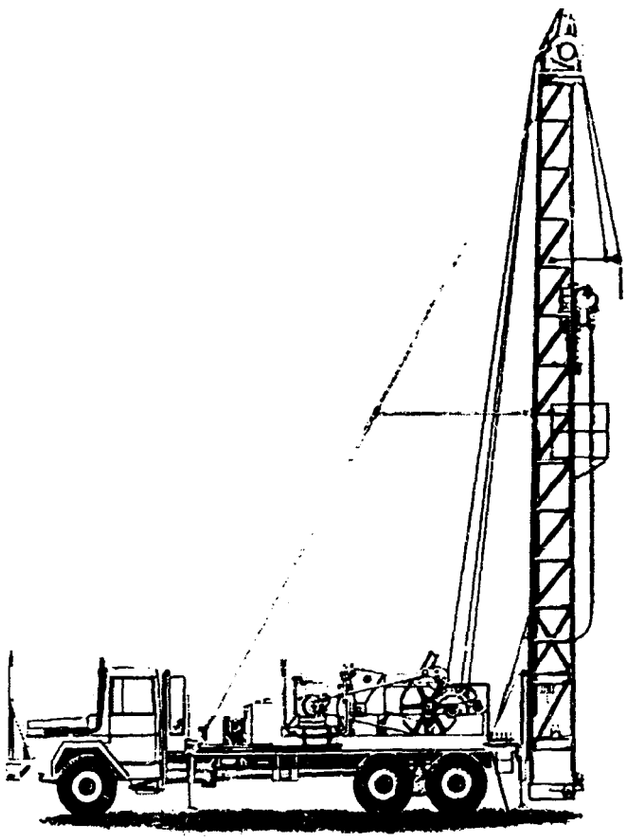
sand reel

spooling capacity	2.000 ft. – $^{3}/_{8}$" ϕ
single line pull	6.000 lbs
speed (bare drum)	330 fpm

mud pump:

duplex piston pump	5$^{1}/_{2}$" x 8"
capacity	840 l/min
max. pressure	24,67 bar

Figure 25(c) Mobile Rotary drilling rig.



folding mast

height:	48 ft.
crown load:	70 000 lb.
table opening:	27 $^{9}/_{16}$"
working clearance:	40 ft.

feeding-chain pulldown

1 st gear –	hoist capacity:	40 100 lb.
	operating speed:	up to 43' 3 $^{1}/_{2}$" /min
2nd gear –	hoist capacity:	19 800 lb.
	operating speed:	up to 98' 4 $^{6}/_{8}$" /min
3rd gear –	hoist capacity:	8 800 lb.
	operating speed:	up to 197 ft./min

power swivel

1 st gear –	torque:	1 000 da Nm
	speed:	0–60 rpm
2nd gear –	torque:	470 da Nm
	speed:	0–125 rpm
opening:		5 $^{7}/_{8}$"

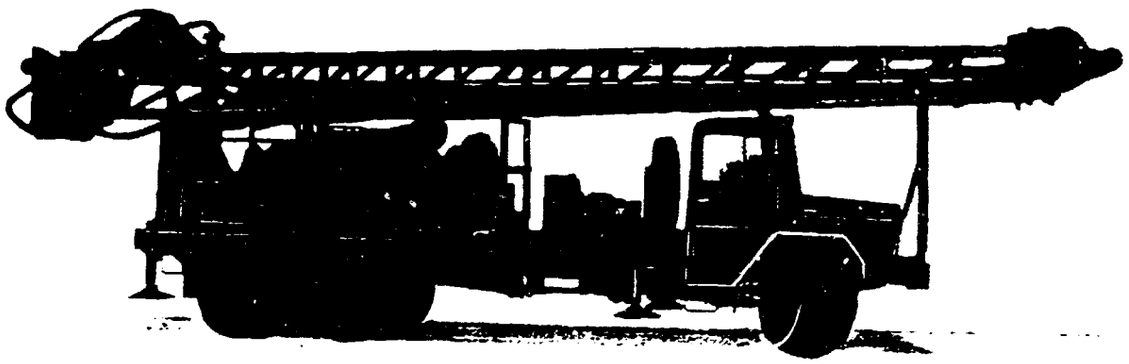
mud pumps

1	duplex piston pump	5 x 6 "
	discharge:	167 Imp.gal.
	working pressure:	320 psi

breakout / make-up device

up to 12 $^{1}/_{2}$", hydraulically operated
for subs, drill collars, drill pipes

Figure 25(d)
Universal Rotary - percussion drilling rig.



hoisting drum
line pull: 11,015 lb.
line capacity: 490 ft.
line diameter: $^{3}/_{4}$"

sand reel drum
line pull: 3,300 lb.
line capacity: 1,968 ft.
line diameter: $^{3}/_{8}$"

bull reel
line pull: 6,600 lb.
line capacity: 1,968 ft.
line diameter: $^{9}/_{16}$"

spudding beam
max. load 5,500 lb.
stroke adjustable up to 39 $^{1}/_{3}$" approx.
number of percussions: approx. 30/min

Figure 25(e) Percussion Device.

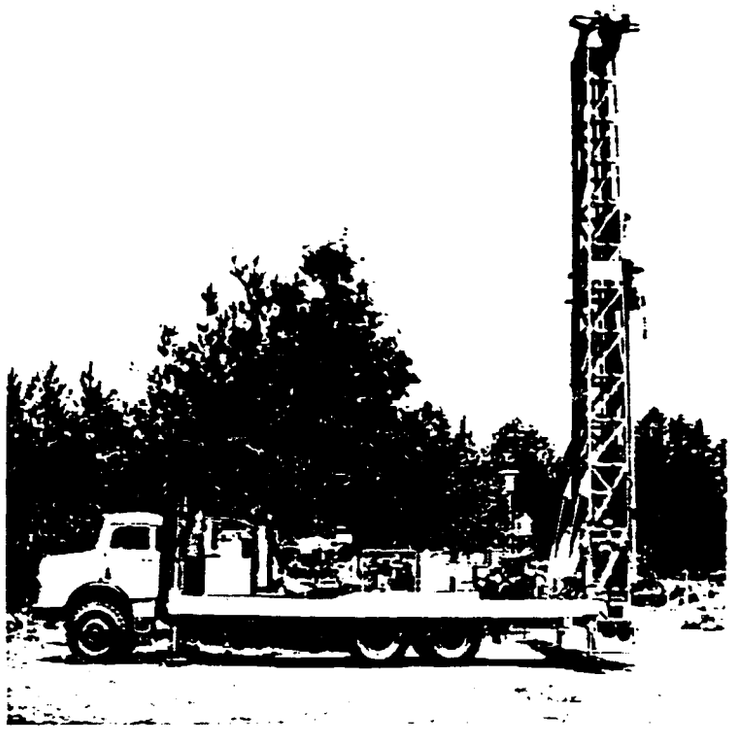


Figure 25(f) Drilling Rig.

combined hydraulic rotary drilling rig for down-the-hole-hammer and circulation drilling

Technical data:

folding mast:

total length:	13	m
effective lifting capacity:	9,5	m
base plate passage:	700	mm
crown capacity:	30	Mp

feed:

1st gear:	0– 0,8 m/min up to 23 Mp
2nd gear:	0– 1,6 m/min up to 23 Mp
3rd gear:	0– 3,8 m/min up to 20 Mp
4th gear:	0–15,2 m/min up to 11 Mp
5th gear:	0– 38,0 m/min up to 5,6 Mp

power swivel:

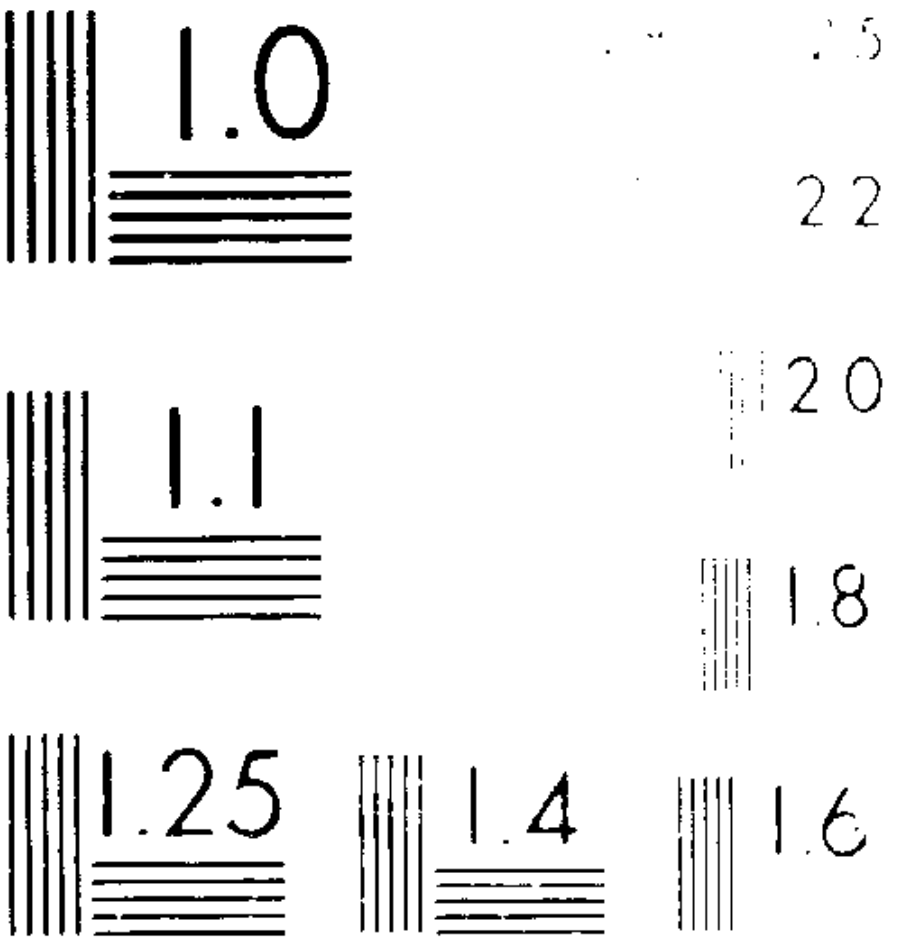
passage:	130	mm
torque:	690	kpm
speed:	0–130	rpm
	removable	

rope winch:

rope speed:	0–100	m/min
rope capacity:	500	m
rope diameter:	10	mm (3/8")
traction power in 1st layer with sixfold traction	14	Mp

hydraulic slip device:

hydraulic rotary tong, power 40 Mp
passage: max. 320 mm
jaws suitable for drill pipe, drill collars, casings, subs


1.0
2.2
2.0
1.1
1.8
1.25
1.4
1.6

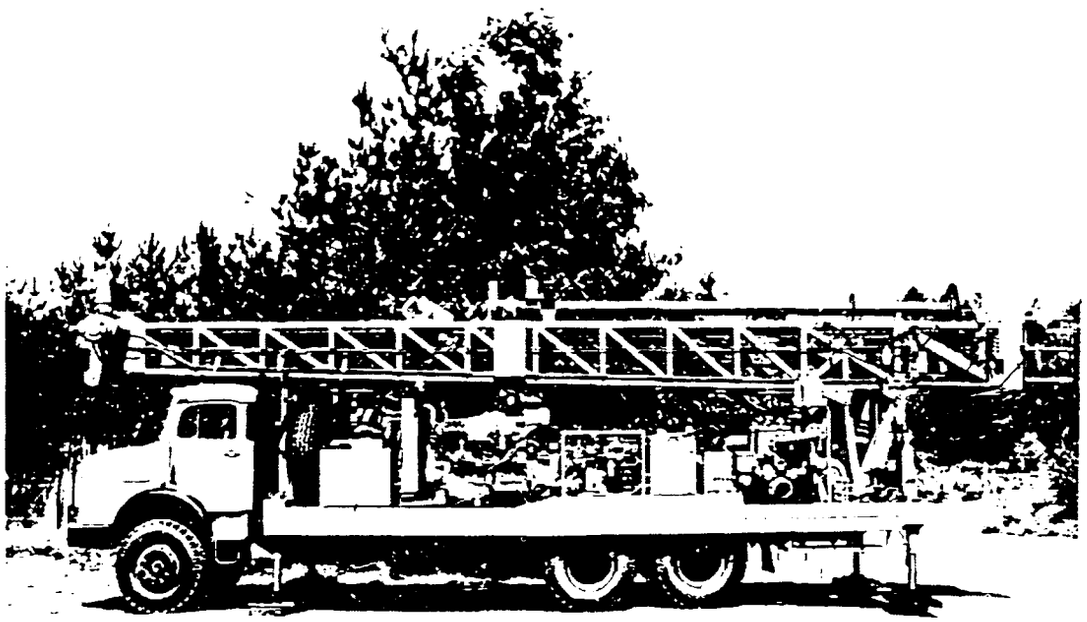


Figure 25(g)
Drilling Rig in driving position

compressor:

discharge:	16,2 m^3/min
pressure max.:	17,6 atm

piston pump:

7 1/2" x 8"	2270 l/min up to 13 atm
6 1/2" x 8"	1690 l/min up to 17 atm
5" x 8"	984 l/min up to 29 atm

drill pipe storage:

storage capacity:	8 pipes of 4 1/2" OD
length:	6 m (20 ft)

alternative:

power swivel NW 150 – torque: 1000 kpm
speed: 0–90 rpm
opening: 150 mm

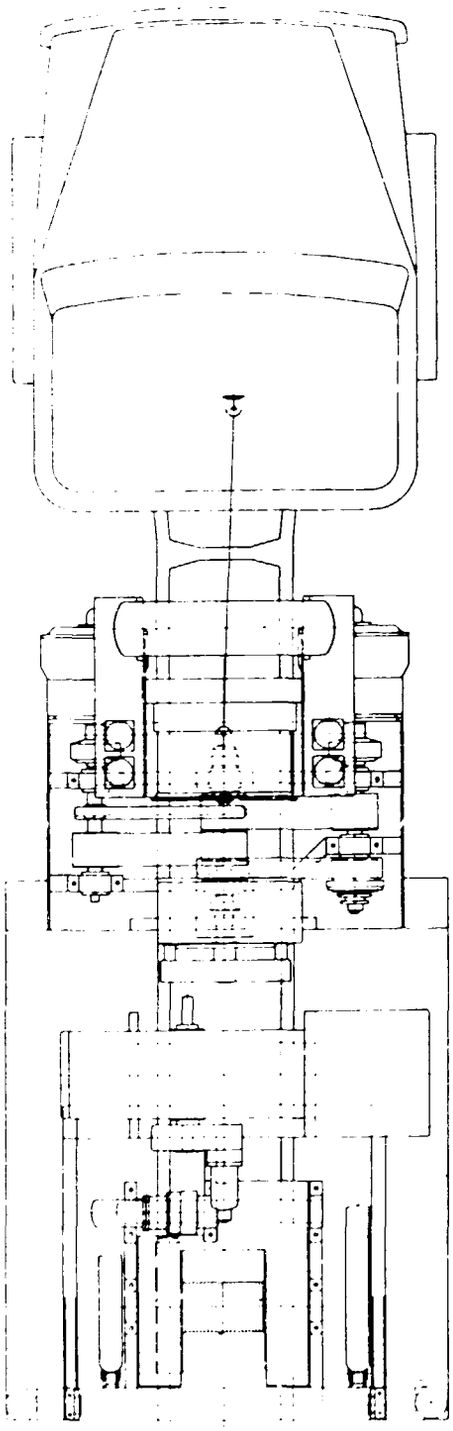
Gearshift allows to drive both, compressor and piston pump, with 30 % reduced revolutions.

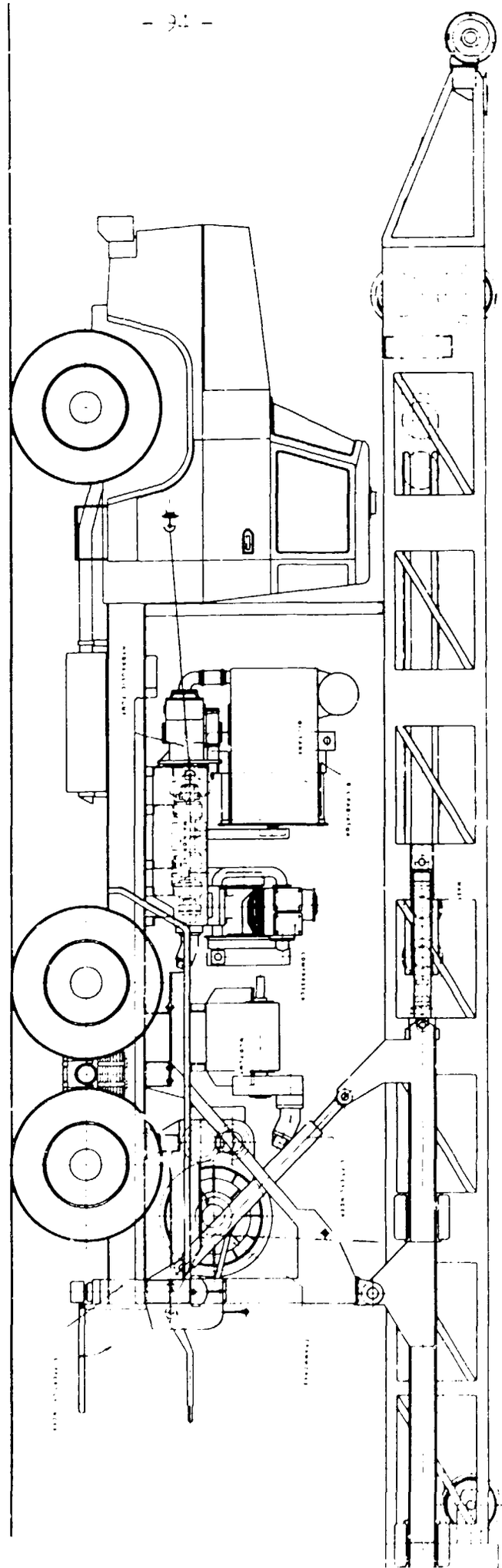
The figures and technical specifications show the great variety of capacities, design and features of water well drilling rigs. One item they do have in common, however, is the compact arrangement of the individual units on the mobile carrier and the simple design of components in comparison with an oil and gas rig.

Some rig components which are commented upon only briefly in this report represent a simpler design of the rotary drilling rig components and are discussed in detail in the oil and gas rig brochure.

Figure 26. Composite drawing of a mobile water well drilling rig.

Figure 26.





I List of Manufacturers

- Water Well Drilling Rigs and Rig Components

Branham Industries Inc., P.O. Box 1750, Conroe, Texas 77301, U.S.A.

Cardwell Mfg. Co., P.O. Box 471, El Dorado, Kansas 67042, U.S.A.

Chicago Pneumatic, Drill Div., 1200 Executive Drive East, Suite 123 Richardson, Texas 75081.

Cooper Mfg. Corpn., P.O. Box 3108, Tulsa, Oklahoma 74101, U.S.A.

Ewbank Mfg. Corpn., 513 North Main, Fairview, Oklahoma 73737, U.S.A.

George E. Failing Co., 2215 S. Van Buren, P.O. Box 872, Enid, Oklahoma 73701

Gardner-Denver, P.O. Box 26208, Dallas, Texas 75226.

Hydra-Rig, 6000 East Berry Str., Fort Worth, Texas 76119.

Industrial Export, 1-3 Scaune Street, Bucharest, Romania.

International Petroleum Services, (Refer to Cardwell Mfg. Co.)

Midway Mfg. & Supply, P.O. Box 4269, Odessa, Texas 79760, U.S.A.

Speedstar Div. of Koehring, 200 Executive Drive, P.O. Box 1606, Milwaukee, Wisconsin 53201, U.S.A.

Walker-Neer Mfg. Co., P.O. Box 2490, Wichita Falls, Texas 76307.

Wichtex Machinery Co. Inc., P.O. Box 2250, Burkburnett Road, Wichita Falls, Texas 76301.

Stewart Ross & Co. Ltd., Sterco Works, St. Albans Road, Sandridge, St. Albans, Herts. AL4 9BS, U.K.

Knebel Hydraulic APS, DK-8420 Knebel, Denmark.

ITAG, Hermann Von Rautenkranz Internationale Tiefbohr GmbH & Co., P.O. Box B.P. 114, Itagstrasse 5-17, D-3100 Celle, W. Germany.

Bomag, Spezialfabrik für Bohrmaschinen und Geräte GmbH, Ströherstrasse 3, D-3100 Celle - Vorwerk, W. Germany.

Portadrill Inc., 3811 Joliet Str., P.O. Box 39-P, Denver, Colorado 80239.

RP Rörprodukter AB, RP-Huset, Box 13109, 40252 Göteborg 13, Sweden.

Celler Brunnenban GmbH, Postfach 91, D-3100 Celle, Triftweg, W.Germany.

II. Technical Institutions

The University of Texas, Austin, Texas.

The American Association of Oilwell Drilling Contractors,
211 North Ervay Bldg., Suite 505, Dallas, Texas 75201.

American Petroleum Institute,
2101 L. Street NW, Washington 20037, U.S.A. or
300 Corrigan Tower Building, Dallas, Texas 75201.

Wirtschaftsverband Erdölgewinnung E.V., Hannover, Fed. Rep. of Germany

Bundesamt für Bodenforschung in Hannover, Fed. Rep. of Germany

Montanuniversität, Leoben, Austria.

Fakultät : Erdölwesen
Lehrkanzel : Tiefbohrtechnik
Technische Universität : Clausthal - Zellerfeld
Lehrkanzel : Tiefbohrtechnik, Fed. Rep. of Germany.

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Fig. 1. Courtesy of Knebel Hydraulic & Winch Trading APS.

Fig. 2. Courtesy of Prakla Seismos Geomechanik GmbH.

Fig. 3. Courtesy of Portadrill Inc.

Fig. 4. (a)&(b) Courtesy of Prakla Seismos Geomechanik GmbH.

Fig. 5. Courtesy of Bomag.

Fig. 6. Courtesy of Prakla Seismos Geomecharik GmbH.

Fig. 7. Courtesy of Bowen Tools Inc.

Fig. 8. Courtesy of Midway Manufacturing & Supply Inc.

Fig. 9. Courtesy of Bowen Tools Inc.

Fig. 10. "

Fig. 11. "

Fig. 12. "

Fig. 13. "

Fig. 14. "

Fig. 15. "

Fig. 16 Courtesy of Midway Manufacturing & Supply Inc.

Fig. 17. Courtesy of Knebel Hydraulic & Winch Trading APS.

Fig. 18. Courtesy of ITAG Celle.

Fig. 19 Courtesy of AGBO GmbH.

Fig. 20. Courtesy of "A Review of Water Well Drilling Methods". K. Cruse.

Fig. 21. Courtesy of Knebel Hydraulic & Winch Trading APS and Stewart Ross & Co. Ltd.

Fig. 22 Courtesy of Stewart Ross & Co. Ltd.

Fig. 23. Courtesy of Stewart Ross & Co. Ltd.

Fig. 24 "

Fig. 25 (a)-(g) Courtesy of Bomag.

Fig. 26 Courtesy of ITAG, Celle.