# CHAPTER 2
# Plant Management

In small plants the operator and manager are usually the same person, or the manager also assists in operation and maintenance. For plants larger than 50kW, there should be two different positions for a manager and operator; but this also depends on the level of management skill of the operator and the interest and commitment of the manager, who may also be the owner of the plant.

The operator is responsible not just for running the plant but also for maintenance and occasional repair. Therefore, he must understand the location and functions of each machine and component. He should be continually listening, testing, and checking for malfunctions and problems. He needs to keep uppermost in mind that prevention is always better than cure - 'a stitch in time saves nine'. His responsibility will normally be for all equipment and structures from source to distribution and will include routine inspections, operation, loading of the system, distribution, and keeping the equipment in good condition.

The manager is responsible for overall management of the plant — including organization, planning, management, budgeting, tariff setting, and bookkeeping.

## 2.1 Management of Operators

### *2.1.1 Selection and Terms of Employment*

The management selects and appoints an operator who is suitable for the job. The operator should be at least literate, and preferably educated up to class 8. He* should be experienced, sincere, and honest and have the capacity to learn and to build good relationships with others. He should be able to do basic trouble-shooting. If not, he should be trained properly by good trainers at a suitable location; including spending time at a running MHP plant.

A suitable local person should be selected as the operator if possible because such people are less likely to leave the job. This may not always be possible, in which case a more experienced person should be selected from outside and a higher salary offered. A better

* Note: Throughout this manual the term 'he' is used to refer to the installer whether male or female.

qualified person will run the project more smoothly, and his higher salary is more likely to keep him there.

An operator can work 8 hours a day normally; but if the plant runs for more than 8 hours per day, an additional operator will be needed to cover leave, illness, and emergencies. (N.B. A person needs rest after eight hours, irrespective of illness and emergencies.) If the owner/manager is capable of running the plant, he may take the place of an emergency operator. Two operators should be appointed if the plant is coupled to agro-processing equipment as well as an electrical generator.

Details of salary, leave, overtime, and other facilities should be made clear at the time of appointment; and it is recommended that a contract be drawn up covering all important conditions so as to avoid disputes later. Terms of resignation and period of notice by both sides should also be specified in the contract. The operator should preferably be appointed during the equipment installation stage of the project and be required to work alongside the installers so that he learns about the procedures for installation, assembly, and so on. If possible, the installers should explain to the operator what can go wrong with each component and how to run the equipment, apply tension to belts, grease the lubrication points, and deal with emergencies.

If the plant is coupled to agro-processing equipment, the operator should also be trained to operate the agro-processing equipment and its accessories, i.e., the shaft pulley, belt, and so on. The operator should know how to change belts safely, and how to fix the alignment and diagnose faults of the agro-processing machines. If the operator leaves the job after only a short time this will not only hinder the day-to-day work but will also cause economic loss to the owner. Thus it is important to select a person who is likely to stay for quite a long period. Adequate incentives, including a good salary, may be helpful in retaining good operators, in addition to considerate behaviour and treatment.

### 2.1.2 *Training*

If the operator (or operator/manager) is hired in the early phases of the project, the subsequent training needs will be less than if an operator were to be hired once the equipment is installed and running. It will be necessary to provide special training if the person is hired after the handover of the project. The owner/community should be aware of the importance of training, without which a project will not run smoothly. The installer provides some basic training at the project site to familiarise the operator with the machines and simple operational procedures. Usually this training is not adequate and additional extensive training should be provided. There are a number of organizations that provide such training throughout the year, often free of charge. The owner/community should make themselves aware of any such opportunities in their country.

### 2.1.3 *Assignment and Supervision of the Operator's Work*

The number of powerhouse operators needed by a micro-hydro project and their work assignments are determined by such factors as the capacity of the project, the complexity of the transmission lines, the headrace, and the penstock. The usual work of the operators can be summarised as follows.

- Regular inspection of the civil work and penstock for damage and need for cleaning
- Flushing/cleaning such things as the intake, the headrace, the desilting basins, and the forebay
- Repairing damage to civil works
- Stabilising/cleaning surrounding areas to prevent landslide damage
- Cleaning and properly maintaining the powerhouse and the equipment in it
- Properly operating the machines within the powerhouse
- Listening for signs of any malfunction or similar problems
- Shutting down the plant if necessary
- Carrying out minor repairs

The job of the manager is to explain these assignments clearly to the operators, to assist and lead them, and to supervise their work, especially during the initial stages of their employment. The manager should also assess the capacity of the operators to learn and perform their duties effectively and amicably. He must also question them and reprimand them if necessary about any laxness in the performance of their duties.

## 2.2 Improving Customer Services

### 2.2.1 *Public Relations*

Both the manager and the operator(s) should speak pleasantly to customers. This is good for business. Any minor problems with customers should be sorted out immediately. For complex problems, a general meeting should be called to which all relevant personnel should be invited. The problems should be discussed and a solution worked out jointly, especially in the case of electrification schemes. Sometimes the operator/manager may himself have to visit local workshops or organizations far from the plant. If he has to leave the plant, another capable person should be instructed to look after the operation and management of the plant. The public should be informed in advance of the reasons for and approximate period of any shutdowns of the plant so that they can make alternative arrangements.

The operator/manager of an electrification plant should visit consumers and discuss with them any problems or complaints they may have regarding the supply; as well as any other issues such as use of electricity, non payment of bills, and low voltage. Every effort should be made to hold such discussions in a cordial manner.

### 2.2.2 *Good Service*

The operator/manager must provide good service to customers on a first-come first-served basis, with a few exceptions. For example, people coming from distant places need to leave for home early, so with the consent of the other customers they may be given priority. When planning the supply of electricity, all houses requesting a fixed wattage supply should be connected first. Only after all such houses have been provided for, should any additional available power be distributed as per the requirements.

Unscheduled and unannounced shutdowns of the plants will lead to loss of revenue, business, and reputation. Therefore, every effort must be made to avoid breakdowns and shutdowns through regular maintenance and by taking care of the small faults and problems that can eventually lead to serious breakdowns.

### 2.2.3 *Load Management*

Sooner or later demand for power will exceed the installed capacity in many plants because, unfortunately, some consumers may take more power then the amount for which they have subscribed. It is necessary to have some sort of monitoring device to make certain that the generating plant is not overloaded and the investor is not suffering losses. It is not practical, however, to install a meter in every household in an MHP scheme. This would only introduce more costs and complications; especially since most consumers will only be subscribing in the range of 50-200 watts.

A flat rate system is generally used in which the consumer pays a fixed rate for the category of wattage for which he/she has subscribed. The maximum power taken by the consumer can be limited through installing some type of current limiting device. Positive thermal coefficient (PTC) controllers are used for the 25 to 50 watt range, electronic current cut-outs (ECC) for the 50-200 watt range, and miniature circuit breakers (MCB) for consumers taking more than 200 watts. Some problems have been experienced with ECC in Nepal, and one of the other two options may be preferable.

Load factors for MHP plants are generally poor, especially in electrification schemes. The electricity is mainly used for domestic lighting. Thus the power demand is for certain hours in the evenings and sometimes in the mornings for a total of about six hours a day. If the available power from the plant is not used during the remaining period there will be less income. Thus the owner/manager should think of ways to increase the utilisation and/or sale of electricity, particularly to industrial or commercial units.

During daytime and the middle of the night, when lighting is not necessary, other end uses can be installed such as small industries, shops with refrigerators, bakeries, and

sawmills. The owner of the MHP plant may invest in such applications himself; or he may encourage or seek others to install such units and buy electricity from him. If industrial applications are to be added, power distribution must be carefully managed so that it is acceptable to such customers.

Sometimes there is a lack of interest in industrial development because of the high costs. The manager should motivate people to install industries, and charges should be reduced if the investors agree to operate during off peak hours. Wherever possible, industrial applications should not be run during peak hours, otherwise there will be voltage fluctuations. Rates for such industries should be decided before the industrial plant is installed.

## 2.3 Financial Management

In order to keep track of income and expenditure, proper records and accounts should be kept of income, expenditure, and savings. Repayments of the loan should be planned based on the projected income and savings, and an adequate amount must be set aside each month for this purpose. Usually only one account book is needed for an MHP plant, but it should have many tables. In general, the records will be kept by the owner or manager of the project. The account book should cover the following.

- Daily records of income and expenditure including outstanding amounts.
- Records of assets (property and stock owned, liabilities/bills or money still to be paid) on a monthly basis.
- Amounts spent on major repairs, new equipment, or business expenses, recorded daily, with monthly totals for each sub heading.
- A final table each year showing all the income, expenditure, outstanding income, and liabilities. This table is needed to determine net profit or loss, and the calculations are useful for planning for the following year.

There are two main systems for keeping the accounts of a project: single entry book-keeping, in which the transactions are recorded once; and double entry book-keeping, in which the transactions are recorded twice. Double entry book-keeping means, for example, that when an MHP project purchases spare parts the account for money spent on spares will be increased, and the bank account or cash account will be reduced. Double entry book-keeping is preferred because it is a more systematic and professional method of maintaining accounts, and can help to identify mistakes very easily. However, the double entry system may be unnecessarily cumbersome for smaller MHP schemes, say below 50kW, and single entries for income and expenditure may be good enough.

The types of information and tables that will be needed are shown in the following sections. The examples given refer to the book-keeping entries used for a typical 30kW MHP scheme. They use the single-entry book-keeping system. Examples of double-entry book-keeping can be found in books about accountancy.

The first page of the account book should contain a table showing details of total project costs and sources of funds (see Table 2.1). The second page should contain a table with details of the loan repayment schedule for easy reference (Table 2.2).

**Table 2.1: Details of Total Project Costs (example)**

| S.N | Description | Amount (Rs) |
|---|---|---|
| 1. | Land purchased | 50,000 |
| 2. | Civil construction (canal, powerhouse, desilting basin, forebay) | 300,000 |
| 3. | Mechanical equipment (turbine, penstock, driving systems) | 335,000 |
| 4. | Electrical (generators, ELC, components) | 1,000,000 |
| 5. | Transportation costs | 100,000 |
| 6. | Installation costs | 200,000 |
| 7. | Operator training | 15,000 |
| | **Total Cost** | **2,000,000** |
| | **Sources of Funds** | |
| 1. | Local contribution (or self investment) | 400,000 |
| 2. | Grant from non-government organization (NGO) | 500,000 |
| 3. | Loan from bank | 600,000 |
| 4. | Subsidy | 500,000 |
| | **Total** | **2,000,000** |

### 2.3.1 *Income and Expenditure Account*

Records of income and expenditure should be kept as shown, for example, in Table 2.3. All income should be dated, and sources of income and expenditure clearly detailed. There will be different expenditures such as salaries, travel, other expenditures, and loan installments. The account book should be updated daily and all transactions recorded in chronological order. Income pending (not yet received) and expenditure (necessary, but not yet paid) may be noted down separately but should not be included in the accounts until they are actually received or paid. The final figures for income and expenditure should be worked out for each month and year.

**Table 2.2: Loan Repayment Schedule for the MHP Plant (example)**
The example given is for a total loan of Rs 600,000 at an interest rate of 16%

| Description | Amount (Rs) |
|---|---|
| Complete repayment in 7 yearly installments | 600,000 |
| 1st yr. ending June, 1997 - repayment of capital | 86,000 |
| Interest on 600,000 @ 16% | 96,000 |
| 1st installment of loan and interest to be paid by 15 July, 1997 | 182,000 |
| 2nd yr. ending 30th June, 1998 - repayment of capital | 86,000 |
| Interest on 514,000 @ 16% | 82,240 |
| 2nd installment of loan and interest to be paid by 15 July, 1998 | 168,240 |
| 3rd yr. ending 30th June, 1999 - repayment of capital | 86,000 |
| Interest on 428,000 @ 16% | 68,480 |
| 3rd installment of loan and interest to be paid by 15 July, 1999 | 154,480 |
| 4th yr. ending 30th June, 2000 - repayment of loan | 86,000 |
| Interest on 3.42,000 @ 16% | 54,720 |
| 4th installment of loan and interest to be paid by 15 July, 2000 | 140,720 |
| 5th yr. ending 30th June, 2001 - repayment of loan | 86,000 |
| Interest on 2,56,000 @ 16% | 40,960 |
| 5th installment of loan and interest to be paid by 15 July, 2001 | 126,960 |
| 6th yr. ending 30th June, 2002 - repayment of loan | 86,000 |
| Interest on 170,000 @ 16% | 27,200 |
| 6th installment of loan and interest to be paid by 15 July, 2001 | 113,200 |
| 7th yr. ending 30th June, 2003 - repayment of loan | 84,000 |
| Interest on 84,000 @ 16% | 13,444 |
| 7th installment of loan and interest | 97,444 |

At the end of each year it is useful to record total incomes and expenditures for such things as loan repayment, repairs, income from electricity, and agro-processing separately on a single page, as shown in Table 2.4. The remaining net balance can be used for (divided between) the personal or family expenditure of the owner/investor, for reinvestment, or to provide a fund for unexpected outlays in the coming year.

For electricity sales, it is unlikely that cash payments will be made at the beginning of every month. Sometimes, money or bills may not be received until the following month. In such cases a record of payments due but still pending should be kept at the bottom of the first page for the month and struck off and entered as a regular entry in the account book when received.

**Table 2.3: An Example of Daily Entries in an Account Book for the Month of January 1998**

| Date | Description | Credit (Income) | Debit (Expenditure) | Balance (Net Income) |
|---|---|---|---|---|
| 1st Jan '98 | Money in hand (opening balance) | 10,000 | | |
| 1st Jan '98 | Income from electricity sale from Area 1, 100 customers @ Rs100 each | 10,000 | | |
| 1st Jan '98 | Salary for two staff @ 1,500 each for December 97 | - | 3,000 | |
| 1st Jan '98 | Travel expenses paid | - | 250 | |
| 1st Jan '98 | Repair and maintenance expenses for canal | - | 500 | |
| 1st Jan '98 | Stationery (postage & telephone paid) | - | 10 | |
| 1st Jan '98 | Other expenses | - | 5 | |
| 2nd Jan '98 | Plant closed due to festival | - | - | |
| 3rd Jan '98 | Sale of electricity from area No. 2,75 customers @ Rs 100 each | 7,500 | | |
| 4th Jan '98 | Sale of electricity from area No. 330 customers @ Rs 100 each | 3,000 | | |
| 5th Jan '98 | Sale of electricity from area No. 420 customers @ Rs 100 each | 2,000 | | |
| | **Total for January 1998** | | | |

### 2.3.2 *Budget for the Coming Year*

It is advisable to prepare a proposed budget for the coming year, this would be 1999 in the examples given. The budget should be based on the income, expenditure, and net profit of the previous two to three years. The proposed budget (Table 2.5) should appear on the page after the table showing the total income and expenditure for the present year (Table 2.4). The table should show the anticipated income and expenditure under the various major headings for the next year and include planning for some additional expenditure, for example, major repairs, expansion of forebay, or cleaning and repair of the penstock. The expenditure should also include the personal needs of the owner and show the net savings, which can be spent on repairs or buying new equipment. In the example shown, the final figures in the table show that the owner will have to arrange an additional Rs 27,000 from his own resources if he decides to go ahead with his investment plans. The owner/community must realise that the actual expenditure (and income) may differ significantly from the figures anticipated.

**Table 2.4: An Example of Total Incomes and Expenditures under Various Headings for 1998**

| Description | Credit (Income) | Debit (Expenditure) | Balance (Net Income) |
|---|---|---|---|
| Balance from 1997 | 21,000 | | |
| Income from electricity | 270,000 | | |
| Income from agro-processing | 180,000 | | |
| Income from sale of agro-processing commodities | 215,000 | | |
| Income from sale of agro-residues | 13,000 | | |
| Staff salaries | | 36,000 | |
| Maintenance | | 18,000 | |
| Repair of generator | | 40,000 | |
| Purchase of spares | | 14,000 | |
| Stationery, telephone | | 600 | |
| Loan instalment (capital + interest) | | 154,480 | |
| Travel & transport | | 19,000 | |
| **Total** | **699,000** | **282,086** | **416,914** |

Net yearly income for 1998 Rs 416,914
Net average monthly income Rs 34,743

### 2.3.3 *Business Expansion*

After the owner/manager of an MHP plant has achieved success in operating and managing the current end-uses optimally, one of his main considerations should be installation of additional end use equipment and/or supplying electricity to additional customers, especially during the off peak hours. In the example shown below, the owner/manager of an existing electrification scheme decided to add some agro-processing equipment to his plant to utilise additional power and thus earn more income. The cost of the new equipment and expected yearly returns are shown in Table 2.6. The figures suggest that the simple payback period will be about four years, and that the simple annual rate of return is about 25 per cent, a healthy profit. There are more complicated methods of financial analysis, but, as the overall investment is small, these simple figures are probably adequate for determining the initial feasibility.

### 2.3.4 *Extending the Supply*

Another method of earning additional income is to extend the electricity supply to areas nearby if additional capacity is available within the plant. This should also mean ad-

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**Table 2.6: Estimated Income and Expenditure (in Rs) for the New Agro-processing Equipment (example)**

| Description | Credit (Income) | Debit (Expenditure) | Balance (Net Income) |
|---|---|---|---|
| **Capital Costs** | | | |
| Cost of grinder, huller, and oil expeller | | 100,000 | |
| Other mechanical equipment (shafts, belts, pulleys) | | 50,000 | |
| Transportation costs | | 25,000 | |
| Civil works (materials, labour) | | 30,000 | |
| Installation costs (materials, labour, testing) | | 15,000 | |
| **Total Capital Costs** | | 220,000 | |
| Estimated average yearly income (from 3 units) | 96,000 | | |
| Salaries | | 24,000 | |
| Maintenance | | 8,000 | |
| Average repair costs per year (4% of total investment) | | 9,000 | |
| **Total (per year)** | **96,000** | **41,000** | **55,000** |

Assuming that the yearly income does not fluctuate severely; the owner would recover his investment in about four years.

After the survey, capital cost estimates can be prepared together with estimates of income and recurrent expenditure. Usually, the net incomes from electrification schemes are quite small, and net yearly incomes of about 15 per cent of the original investment may be considered adequate. If it is necessary to obtain a loan at normal interest rates from a financial institution, then the project may not be viable and the possibilities for getting a subsidy or grant from a donor agency should be explored.

## 2.4 Organizing Maintenance

In order to maintain the MHP plant in the best possible condition, it is essential that routine maintenance be carried out in accordance with a predetermined schedule. Manufacturer's maintenance schedules for items such as bearings and generators should be followed carefully. Routine preventative maintenance will result in extended plant life and reliable operation; and reduce the long-term operating costs. Waiting for the plant to

break down and then trying to fix it will result in increased long-term operating costs, reduced plant life, and user dissatisfaction.

The manager should instruct the operator clearly to check items outside and inside the powerhouse on a regular basis to ensure reliable operation. He should also randomly supervise his work. Any problems should be rectified as soon as possible to prevent them from getting worse.

### 2.4.1 *Maintaining a Stock of Spares*

A micro-hydro scheme needs repair and maintenance quite often, and the manager is responsible for organizing this. Some spare parts, such as bearings, tools, grease, oil, and belts, should always be kept in stock so as to avoid delays in procuring them when they are needed. The plant should have a separate locked storage room or a cabinet for tools and spares which is kept clean and secure. Bearings should be stored in the original packing; or coated with grease if this is not possible. Vee or flat belts need to be hung on a wall and not left coiled on the floor. Electrical parts should be packed, labelled, and stored away from moisture.

It is recommended that at least one set of the following spare parts should be kept in stock for an MHP plant.

| | |
|---|---|
| • Turbine bearings | 1 set (usually two) |
| • V-Belts | 1 set |
| • Flat belts | adequate length, enough to cover the longest belt length used in the plant. |
| • Grease | 1 kg |
| • Generator bearings | 1 set |
| • Gaskets | 1 set (for all locations) |
| • Penstock nuts, bolts | 5% of total installed |
| • Expansion joint gasket | 10% of total installed |
| • Fuses | all installed sizes |

In addition, if the funding permits, one turbine runner and an automatic voltage regulator (AVR) should also be kept in stock as spares.

### 2.4.2 *Maintenance Tools*

Good quality tools are essential for good maintenance of the MHP plant. The manager should be responsible for keeping the tools properly and should instruct and guide the operators to use them correcly. The following suggestions will help keep the tools in a good useable condition.

- Clean tools after use and return them to the storage area.
- Lubricate them to prevent corrosion wherever necessary.
- Keep a record of tools.
- Do not throw tools, handle with care.
- Use tools as they are meant to be used.
- Check condition of tools and do not use damaged tools.
- Purchase new tools or repair them if they become unusable.
- Store hand tools on a board or in a cupboard.
- Store measuring instruments (multi-meter, vernier, etc) in a cupboard or draw to protect them from dust and impact.

The spares and tools should preferably be kept in a separate room under lock and key, and their issuance and re-storage should be recorded in the log book or a separate register. Figure 2.1 shows the ideal type of storage arrangement for tools.

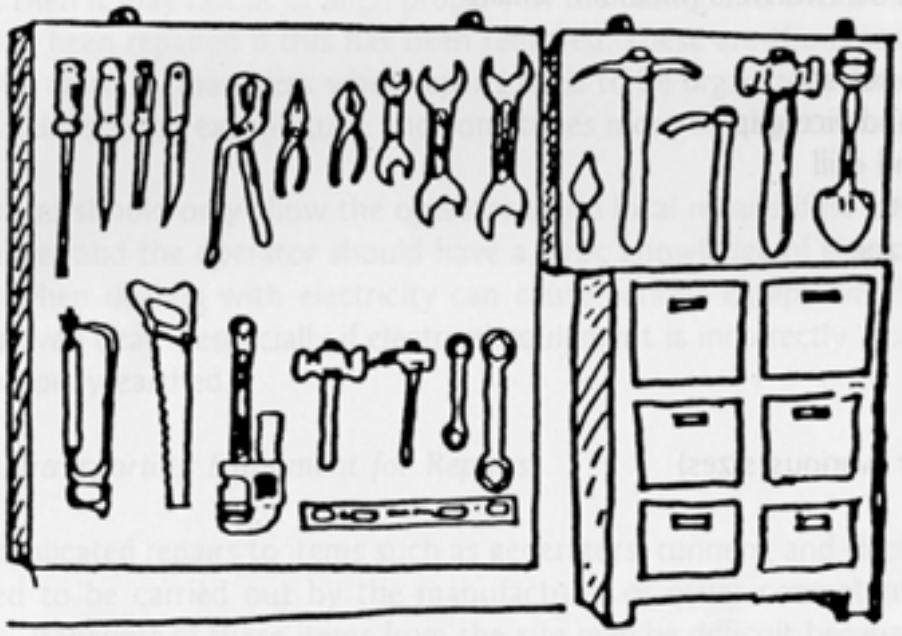

**Figure 2.1: Ideal Storage Arrangement for Tools**

### *2.4.3 Necessary Tools*

The basic tools needed for maintenance of an MHP plant are listed below.

Electrical

- Combination pliers
- Nose pliers

- Soldering iron and solder
- Hacksaw
- Line tester and multi-meter
- Torch or portable lamp

In addition, if funding is available; a wire puller and safety belt should also be kept in stock.

Mechanical

- Hammer
- File set (flat, round, etc)
- Open and ring spanners, one set each
- Slide wrench (200 mm or 300 mm)
- Screwdrivers (large, small)
- Phillips head screwdrivers (medium, small)
- Grease gun
- Metric Allen key set
- Bench vice and vice grip
- Portable hand drill
- Twist drill set
- Measuring tape
- Paint brush
- Oil can
- Hacksaw
- Wire brush
- Emery paper (various sizes)

Civil

- Pick
- Spade
- Shovel
- Crow bar (lever)

## 2.5 Organizing Repairs

### *2.5.1 Procedures to Deal with a Breakdown and Fault Diagnosis*

When a breakdown occurs, necessary steps need to be taken to prevent further damage to the plant and possible injury to staff. This usually requires shutting down the plant

until the fault is diagnosed and the problem is rectified. Refer to the 'Manual for Maintenance and Repair of MHP Plants' for problem diagnosis and corrective action.

### 2.5.2 *Disassembling and Assembling Equipment*

Before commencing disassembly work, always study the layout of the unit to be dismantled carefully. Decide which components need to be removed and which do not. The manager should decide whether a faulty part or machine can be repaired locally, or whether it should be transported to the manufacturer. If it is not repairable locally, and the operator is not experienced, then components that do not need to be removed should not be removed. With any disassembly and re-assembly there is always a chance of damage to equipment and waste of time. However, in some situations in which the transportation has to be manual, some heavier parts may be removed and not transported. For example, if the turbine runner or shaft is damaged, then it may be cumbersome and unnecessary to carry the whole turbine to the repairers. On the other hand, if the shaft needs to be repaired, then it may not fit or align properly in the casing and/or bearing of the housing after it has been repaired if this has been removed. These are the types of decision that need to be taken by managers when repairs need to be organized. Wrong decisions can result in delays, extra expenditure, and sometimes more damage to the equipment.

The manager should only allow the operator to do local repairs if he is well experienced. The manager and the operator should have a basic knowledge of electricity. Minor carelessness when dealing with electricity can cause serious equipment damage, personal injury, or even death, especially if electrical equipment is incorrectly assembled or wired, or not properly earthed.

### 2.5.3 *Transporting Equipment for Repairs*

More complicated repairs to items such as generators, runners, and electronic equipment may need to be carried out by the manufacturer or other competent repairer on his premises. Transport of these items from the site may be difficult because of poor access. It is important that before transportation care is taken to:

- pack equipment well using timber or thick cardboard;
- protect equipment from water damage by wrapping it in plastic;
- print 'right way up' and 'handle with care' signs; and
- inform the persons responsible for transport about the need for care in handling, especially when loading and unloading from vehicles.

Figure 2.2 also illustrates a few 'rights and wrongs' for transportation of equipment.

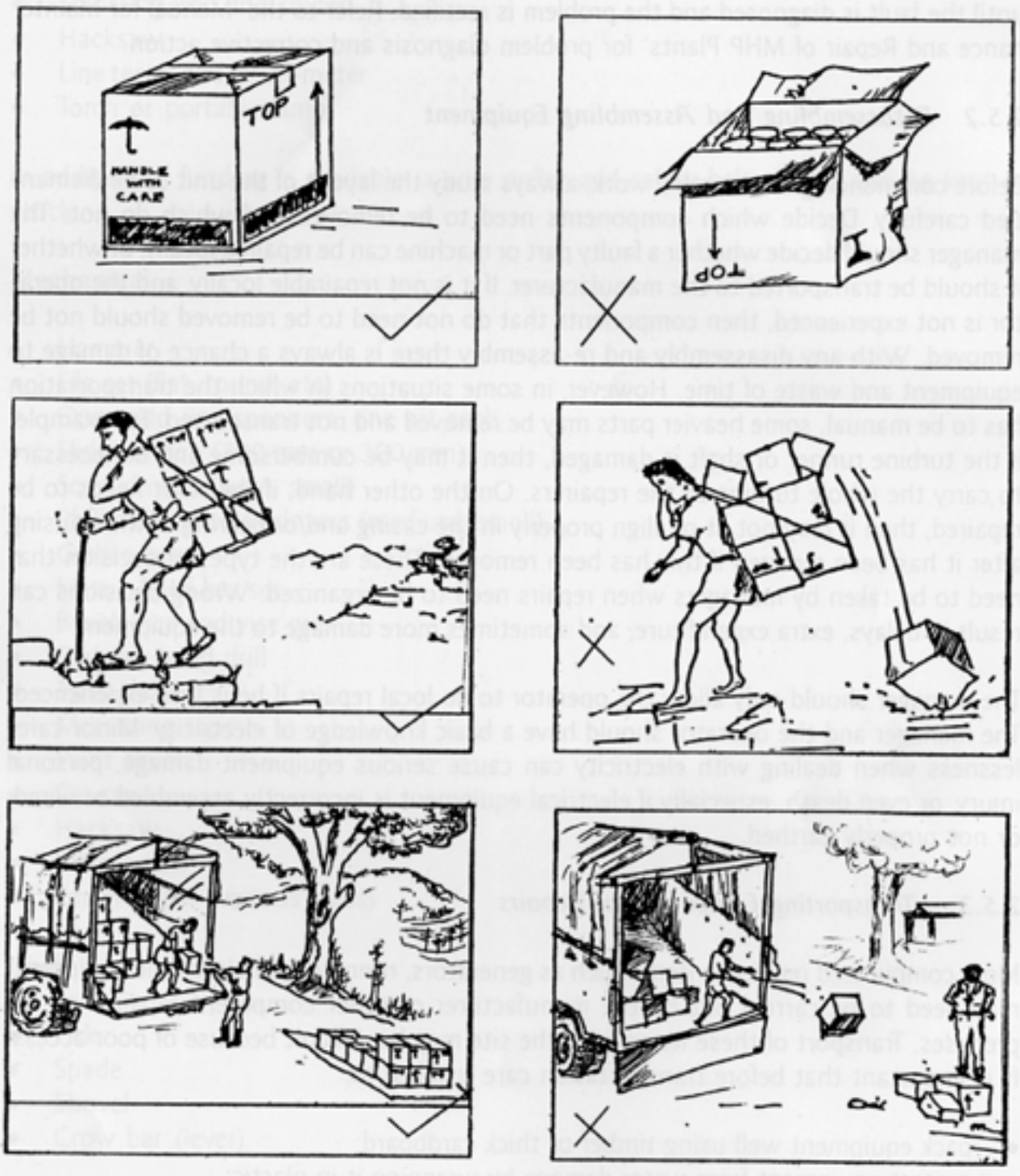


**Figure 2.2: Right and Wrong ways to Transport Equipment**