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

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REPORT ON THE PROBLEMS INVOLVED IN PROVIDING FOR COMMUNITY RECEPTION OF TELEVISION IN NON-ELECTRIFIED AREAS OF DEVELOPING COUNTRIES, AND AN EXAMINATION OF POSSIBLE SOLUTIONS 1/

prepared by the

United Nations Educational, Scientific and Cultural Organization

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A REPORT ON THE PROBLEMS INVOLVED IN PROVIDING FOR COMMUNITY RECEPTION OF TELEVISION IN NON-ELECTRIFIED AREAS OF DEVELOPING COUNTRIES, AND AN EXAMINATION OF POSSIBLE SOLUTIONS

1.0 INTRODUCTION

In comparison with the problem of providing radio in non-electrified areas, the corresponding television problem is many times more difficult. In the case of radio, both the increasing replacement of the valve by the transistor and the demand for portable receivers in the industrialised countries have resulted in the large-scale production of portable radio receivers which can be operated with a very sensitive built-in aerial for as long as half a year or even more from a few one flashlight batteries. Since such receivers can be used anywhere in the world where signals of the required strengths can be established, the problem of satisfying the requirements of the non-electrified developing countries is reduced to one of assembling a standard type of transistor receiver in a suitable form.

The case of the television receiver is, however, quite different. In the first place, whereas the power required to operate a loudspeaker which can be heard by quite a large community can be 1 watt or less, the power required to operate a picture tube requires many watts, the actual amount depending on the size of the tube. As a result, even in the case of an all-transistor television set, only a comparatively small picture, capable of being seen by less than ten people even for general viewing purposes, can be obtained from a relatively large and expensive primary battery. This means that for larger audiences necessitating comparatively large pictures, an external electrical supply must be provided. In an electrified area this requirement creates no problem because television receivers designed to operate from a mains supply are readily available. Up to the present, these receivers have been of the all-valve type because it is more economical to make them so than to use transistors. As there is no demand for receivers of the size suitable for a fairly large audience to operate other than from the mains, a significant replacement of valves by transistors in television sets used in industrialised regions will take place only when, for the same specification, an all-transistor television set using a larger picture tube can be made for, near enough, the same cost as an all-valve one.

In the case of a non-electrified region, however, where the power supply to the television receiver has to be provided as part of the installation, the economic considerations which decide the issue between the all-valve and the all-transistor receiver can well result in a different conclusion from the one reached in an electrified area. In non-electrified areas the deciding factors, in addition to the degree of complexity involved, are the initial cost of the combination of power supply and television receiver together with the running costs.

As there are no reasons why either the aerial systems or the television receivers (be they all-valve or all-transistor) required for non-electrified areas should differ fundamentally from those used in electrified areas, it is the provision of the electrical supply for any chosen receiver which has to be regarded as the special problem of these areas. It is, therefore, a study of this problem which is the main subject of this report. On the assumption that a solution to the problem is a present need, only those supply methods available today in a practical form are considered.

Since no particular country or type of community has been specified, it has been necessary, instead of restricting the report to a study of a few selected methods of supplying power, to treat the subject on lines broad enough to make possible the selection of the combination of receiver and power supply best suited to any given circumstances. It is visualised that, although there could be situations in which the choice is restricted to a single combination, in general more than one possibility will be suggested by the report. In such circumstances it is assumed that a detailed study will be made of each possibility in the light of the known conditions before a final choice is made.

It is realised that, even though quite a number of different supply methods are proposed, there may well be regions where they are all unusable because the degree of skill required to operate and maintain any one of them will not be available. Nevertheless, although there is knowledge of very advanced methods requiring very little skill (in some cases, even no skill) to operate them, they are not discussed in this report because it is felt to be premature to do so before any of them has been produced in a form which could be considered practical for the supply of power to a television receiver.

In order to make possible a comparison of the different possibilities described in the report, it has been necessary to make an estimate of both the prices of the various items of equipment involved and the annual charges which have to be incurred to maintain the power supply. The equipment prices, although quoted in U.S. dollars, have been derived, in the main, from British sources. Since, without knowing either the actual suppliers of the items concerned or the quantities to be purchased, it is not possible to know the trade terms on which the goods can be obtained, the prices quoted are based on current list prices.

As far as the annual charges are concerned, since there is no knowledge of the region where a receiver will be installed, the nature of its population, or the number of viewing hours, it has not been possible to do more than guess the likely expenditure on such items as fuel, transport, labour and annual depreciation (fixed by the expected life of the items of equipment comprising the installation).

It is realised that there will be differences between the estimated costs and those which will be established for a known set of circumstances. Nevertheless, it is hoped that although such differences will modify the costs given in the report for the individual cases, they will not alter materially conclusions based on relative costs.

2.0 PICTURE SIZE

Before a decision can be made regarding the form which the power supply should take,

(a) the size of the receiver necessary to meet the demands of the community in question and

(b) the power required to operate this receiver,

must be established. As a first step, therefore, it is necessary to examine the way in which these quantities can be evaluated.

The size of the community which can be served by a single television receiver is directly proportional to the area of the picture tube face. In all modern receivers the shape of this face is rectangular, and the length of the diagonal can be taken as a measure of the size of the picture. For a given size, the number of possible viewers is determined by the maximum angle of view and the furthest distance from the receiver for which the picture is still acceptable. The relationship between these two quantities and the number of viewers (n) is shown in Fig.1 to be given by

$$n = \pi \times \frac{d^2}{a} \times \frac{\theta}{180} ,$$

where d = viewing distance,

θ = viewing angle,

and a = area allotted to each viewer.

Tests made with a 23" picture tube indicate that, for general viewing purposes, possible values for d and θ are 30 ft. and 50^o, respectively. On the assumption that 5 sq. ft. is allotted to each viewer, the corresponding value for n is 155. As some places will be lost immediately in front of the receiver, the number of viewers which can be placed around a 23" receiver will be taken as 150 in further calculations. It is realised that this number will not always be achievable because, in a given situation, the actual size of audience possible will depend on the amount of ambient light falling on the tube face, the height above the ground of the picture, the degree of fine detail normally expected to be seen, and the way in which the viewers are packed. For example, if the receiver is required for teaching purposes (as opposed to general viewing), it would not be practical to have either a viewing distance exceeding 20 ft., a viewing angle exceeding 40^o, or an area allocation per viewer of as little as 5 sq. ft. In fact, it is probably unrealistic to assume that an audience of more than 30 people can be gathered around a 23" receiver for educational purposes.

It is assumed that the loudspeaker is placed either in the receiver cabinet itself or externally so as to face the audience, and that the power supplied to it provides adequate audio output for the number of people present.

As the value of (n) is directly proportional to the area of the picture tube, the number of viewers corresponding to any picture tube size (s) can be calculated from the relationship

$$n = 150\left(\frac{s}{23}\right)^2 \text{, for general viewing,}$$

$$\text{and } n = 30\left(\frac{s}{23}\right)^2 \text{, for educational viewing.}$$

Table 1 gives the number of viewers corresponding to most of the tube sizes normally manufactured for the domestic market.

Table 1

Tube Size	Number of Viewers	
	General	Educational
5"	7	2
9"	23	5
11"	34	7
16"	70	14
19"	102	20
23"	150	30
25"	177	35

3.0 THE POWER REQUIRED

Once the size of tube required for a given audience has been established, the power required to operate the television receiver equipped with such a tube can be evaluated. For a given type of receiver (that is, all-valve or all-transistor), the power consumption depends on the size of the tube and its characteristics, the audio output and the supply voltage. For the all-transistor receiver, Table 2 gives the size of tube expected to be found in practice to correspond to the various consumptions indicated.

Table 2

Power Consumption	Tube Size
Up to 5 watts	5"
10 watts	9"
15 watts	11"
25 watts	16"
30 watts	19"
35 watts	23"
40 watts	25"

In such receivers, the present practice is to have a supply voltage of 12 volts D.C because

(a) A standard lead-acid car type battery can be used.

(b) It is a convenient voltage for most of the circuits.

There is a possibility, however, that, in the future, transistors will be developed to give a better answer for the larger picture tubes (23" and above) with a supply voltage of 2 x 12 volts.

For comparison purposes, it should be noted that the consumption of a 23" all-valve receiver is about 150 watts, normally obtained from a 200/240 volt supply. The consumption of an 11" all-valve receiver for the same supply is about 80 watts. This is about the smallest size for the present-day all-valve receiver.

4.0 THE CHOICE OF RECEIVER

From Table 1 the minimum tube size can be established for a given community of less than 200 people (or 40 for teaching purposes). The actual tube size chosen nearest to this minimum will depend on (a) the economics of the total installation * and (b) the advantages to be gained by having a receiver size which is or will be manufactured in large quantities in industrialised regions. These advantages are :-

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* For example, although the nearest size for 100 viewers is 19", it does not automatically follow that this is the best choice economically. This is because, in practice, the only realisable saving in the overall costs compared with a 23" receiver lies in the difference in cost between the two receivers. As this difference is of the order of 10% (about 20 dollars for an all-valve receiver), the saving may not be considered sufficient to justify the loss of a potential 50 viewers.

(1) Such a receiver will be cheaper than one for which the demand is relatively small or which has to be developed specially for non-electrified areas.

(2) The supply of spares and maintenance will be much easier and cheaper for a receiver produced in large quantities.

(3) The manufacture of a standard type of receiver either in part or as a whole will be much easier to undertake in the developing countries because they will be able to build on experience gained in the industrialised countries.

The choosing of a receiver which is basically of a standard type should not be difficult because, as there is no reason why the characteristics, or the strength of the signals to be received, or the picture quality required, should not be the same in a developing country as in an industrialised one, the specification of the receiver, whether it is all-valve or all-transistor, will be basically the same in both cases. It may not, however, be possible to have identical receivers for both regions for the two following reasons :-

(1) The receiver used in the developing country will probably have to cope with the difficulties arising from the heat, humidity and possible damage by insects of tropical regions. The ways in which these difficulties can be overcome are well known, and, in

fact, there are today many all-valve television receivers operating successfully in tropical countries. Although, up to the present, comparatively few all-transistor television receivers exist in tropical countries, there is no reason why, provided the correct steps are taken in the design, such receivers will not function as satisfactorily in the tropics as the all-valve receiver.

(2) As the receivers in the developing countries will be used for community viewing, the following additional points could arise :-

(a) The audio output obtained from a standard 23" receiver, although adequate for domestic viewing, might not be sufficient for larger audiences.

(b) Some arrangement for tilting the receiver could assist in the achievement of the best viewing conditions.

(c) To avoid possible tampering with the controls, lockable doors might have to be fitted to the cabinet.

Receivers fitted with tubes of all the sizes listed in Table 1 are manufactured in the industrialised countries, the most popular one being an all-valve receiver using a 23" tube. At the present time, a corresponding 23" all-transistor receiver would be at least 50% more expensive. It is visualised, however, that the rise in the production of the necessary transistors which will take place in the coming years will result in the all-transistor receiver costing no more than the corresponding all-valve by about 1971. It is not known exactly what the price difference will be in the intervening years, but it is expected that it will fall to the order of 30% by about 1968. Although the present price difference does not justify the manufacture of the larger sized all-transistor receivers in large quantities, some manufacturers are already producing, and others are developing for production, such all-transistor receivers in order to gain the experience necessary for full-scale production later on.

In the following, it will be assumed that, to begin with, there is a free choice between the all-valve and the all-transistor receiver. Further, in order to simplify the argument, it will proceed on the assumption that the size of community demands a tube size in the neighbourhood of 23". It is assumed that, if in actual fact the community corresponds to one of the other tube sizes listed in Table 1, there will be no difficulty in adapting the conclusions to the size in question. The problem of larger communities (above say 200 for general viewing or 40 for educational viewing) is examined separately in section 9.0.

The decision whether the 23" receiver should be all-valve or all-transistor has to be deferred until the economics of the individual power supply possibilities for each type of receiver has been studied. This is carried out in the discussions which follow.

5.0 POWER SUPPLY CONSIDERATIONS

The present known ways in which power could be made available, in a practical form, for supplying television receivers in non-electrified areas, fall into the following categories.

(a) From a primary battery. Such batteries are expendable because they can only be discharged.

(b) From a secondary battery. As these batteries are reversible in action, that is they can be charged and discharged, they can have a relatively long life.

(c) From a generator driven by a prime mover.

(d) From a combination of (b) and (c).

As the maximum power which it is practical to derive from a standard type of primary battery is less than 5 watts, such a power source is normally confined to television sets fitted with picture tubes not exceeding [illegible]" in size.

So long as the supply voltage does not exceed 24 volts, the secondary battery can provide a practical and economic answer to meet the power consumption needs of any television receiver of the all-transistor type. Although it is not impossible to meet the power requirements of an all-valve receiver by using secondary batteries, such a solution would not be a practical proposition. This is because the required 240 volts would have to be obtained by using either a large number of relatively low capacity 12 volt batteries alone or a 12 volt battery of very large capacity operating some form of voltage converter. Even if, in either case, the necessary charging and maintenance arrangements could be made, calculations of the type carried out in the following sections would show that the comparatively high initial expenditures and annual charges involved make both methods unacceptable economically.

There are many different types of rechargeable batteries available, each with its own special features. The one most frequently found in general use is the lead acid car battery type. Although other varieties such as nickel-cadmium, silver-cadmium, manganese-zinc and silver-zinc are, in general, lighter, more robust and of longer life than lead - acid batteries of the same capacity, their use is normally confined to those instances where a cost of about 5 to 10 times that of a corresponding lead-acid battery can be justified.

The generator, when driven by a suitable prime mover, does not suffer from the practical limitations of the secondary battery, and there should be no difficulty in supplying sufficient power to meet the demands of any type of television receiver. The type of prime mover most commonly met is an engine fuelled by either petrol or oil, and many applications have been found for the small engine/generator set of the type required for a television receiver.

In addition to the supply of power by either a secondary battery or a prime mover/generator set operating alone, a combination of the two can be used to meet the power requirements of the all-transistor receiver. Possible advantages of using such a combination are discussed in detail later on.

From what has been said in the foregoing, it follows that, whereas it is only practical to derive the power supply for an all-valve receiver from a prime mover driving a generator, an all-transistor receiver can, in addition, derive its power from a secondary battery operating either alone or in combination with a driven generator. In the following, the considerations which govern the choice of the power source are examined in detail in connection with the requirements of both a 23" all-valve and an all-transistor receiver.

The examination is intentionally limited to methods involving items which are well known and have been manufactured over many years in large quantities. This is done because it is believed that, for the areas under consideration, it would be unwise to contemplate using any apparatus which (a) has not yet been proved, at the least in industrialised areas, to be usable under normal domestic conditions, and (b) cannot yet be manufactured in relatively large quantities for a reasonable price. For these reasons those devices which have been explored in recent years, mainly in connection with space vehicles, are considered in their present state of development to be unsuitable for the purpose of providing power for television receivers in developing countries. Under this heading fall such ways of generating power as thermo-electric generators, thermionic converters, fuel cells, solar energy, nuclear sources and magneto-hydrodynamic generators.

6.0 POWER SUPPLY FOR AN ALL-VALVE RECEIVER

Since the normal power supply for an all-valve receiver is an alternating current having a frequency of 50 or 60 cycles per second, the generator driven by the prime mover will have to be an alternator giving an output of not less than 150 watts at 200/240 volts and having a frequency of 50 cycles per second (or 60 cycles per second). In order that a steady picture of good quality be obtained from the television receiver, it is essential that both the supply voltage and the frequency should remain constant to within small tolerances for the whole of the programme duration. To achieve this the prime mover must be powerful enough to drive the generator at a, near enough, constant speed for possibly many hours irrespective of possible load fluctuations, and the generator must have sufficient reserves of power to provide a constant output at all times. There are many small petrol engine/ alternator sets manufactured in a number of countries capable of meeting these requirements. A typical set uses a 4-stroke petrol engine of about 100 c.c. capacity coupled to a 500 watt alternator. It is fitted with a mechanical governor which automatically controls the engine speed and keeps it constant for all outputs up to about 350 watts. For such a set, it can be expected that the voltage output will not vary by more than ±5% and the frequency will remain constant to within one cycle per second after about ten minutes from starting. The petrol consumption of the engine under normal running conditions is about one pint an hour.

For the low engine powers required to drive the generator (about 1 b.h.p.) the petrol engine is more suitable than the diesel. At such low powers the starting characteristics of the diesel are not good and the action of the flywheel would not be effective enough to give the constant speed performance of the small petrol engine. On the other hand, for powers exceeding 2 b.h.p., the diesel engine, in spite of its higher cost, may be found preferable to a petrol engine of the same power because it consumes less of a cheaper fuel and has a longer life.

It is not possible to give the exact cost of a petrol engine/alternator set because this seems to depend on the manufacturer. It would be reasonable, however, to assume that a suitable set can be obtained at a cost of the same order as that of an all-valve receiver. Also, the fuel costs in a given area can be evaluated only when the viewing hours and the cost of petrol are known. For example, for 15 hours of viewing each week and petrol at 60 cents per gallon, the annual fuel cost would be, near enough, 40 dollars. In addition to this must be added the annual charges for maintenance (such as replacement of faulty parts, regular decarbonising and cleaning) and for depreciation.

It is difficult to know what the actual depreciation charges will be because the useful life of a given engine depends not only on the work it is called upon to do but to a large extent also on the way in which it is maintained. In general, (a) the heavier the construction of the engine, (b) the higher the b.h.p., (c) the lower the speed and (d) the greater the diameter of the pistons, the longer the life is likely to be. On the other hand, as the cost of the engine has to be considered, there will have to be accepted a compromise between the engine's life and cost. For the type of engine which is visualised and the conditions under which it is likely to be used, it is considered unrealistic to assume a life of more than three years for a regular working period of about 15 hours a week. It is expected that after three years the engine/generator will be replaced as a whole as this will probably be cheaper than the fitting of a new engine to the old generator. Further, in order to avoid possible exaggeration of the annual charges, it will be assumed that the annual depreciation charge includes the annual maintenance charges as well. (This assumption will also be made in all subsequent calculations where maintenance charges are likely to be involved.)

For assumed list prices of an all-valve 23" television receiver and a petrol engine/alternator of 180 dollars each, the annual fuel costs, on the foregoing estimates, would amount to 33% of the receiver cost. The same percentage would apply for the annual charges as well.

Summarising, the purchasing price of the all-valve receiver together with its power supply would be 360 dollars, and the total annual charge for providing the power would be 120 dollars.

In this and subsequent calculations the annual depreciation charge for the television receiver itself (all-valve as well as all-transistor) is ignored because, as the life of a television receiver should be more than five years, the replacement receiver (and therefore the cost) will probably be the same even if the original receiver was an all valve one. Consequently, since the annual depreciation charge will be the same whichever type of receiver is first installed, this charge will play no part in any calculations made involving a comparison of the different power supply possibilities.

7.0 POWER SUPPLY FOR AN ALL-TRANSISTOR RECEIVER

It has been pointed out that, whereas for practical reasons the power supply possibilities for an all-valve receiver are confined to the use of some form of engine/generator set, the possibilities for an all-transistor receiver include, in addition to an engine/generator set, the use of a 12 volt battery either by itself or in combination with a generator driven by some form of prime mover.

As far as the engine/generator set for a 23" all-transistor receiver is concerned, although the power required is only about one-quarter of that supplied to a 23" all-valve receiver, it is not advisable to use a petrol engine of lower capacity. This is because the petrol engines normally manufactured with capacities of less than about 100 c.c. tend to be erratic in operation and of comparatively short life. As far as the generator is concerned, the prices normally quoted for outputs of less than 500 watts appear to show very little saving compared with the price of a 500 watt generator. Apparently, it is the normal practice to use the same parts for all small output generators as it does not seem to pay to fabricate special parts for the smaller machines. Therefore, the petrol engine/alternator used to supply an all-transistor receiver will not differ from the one used for the all-valve receiver except that the alternator voltage could be 15 volts (to produce an output of 12 volts to the receiver) instead of 240 volts.

It is better to have an alternator rather than a dynamo because, with efficient rectification and filtering, it is easier to obtain both a lower ripple voltage and a freedom from surges from an alternator than from a dynamo. A ripple voltage exceeding about 40 mV. on the voltage applied to the transistors is likely to produce picture distortion, and relatively high surge voltages can damage the transistors.

As, however, the petrol consumption and the annual costs of the petrol engine/alternator are the same for an all-transistor receiver as for an all valve one, there would be no point in choosing the former until the economics of the transistor brings its price much nearer to that of the all-valve receiver than it is likely to be for the next five years.

Although the use of an all-transistor set cannot, for the time being, be justified when its power supply is derived from a petrol engine/alternator, it does not necessarily follow that none of the other power supply possibilities can provide the means of recovering the higher cost of the all-transistor receiver. In the following, the other possible supply methods are analysed in order to determine whether any of them makes possible the recovery of the additional cost. For this purpose the envisaged 1968 higher cost percentage of the all-transistor receiver mentioned in section 4.0 will be used. This is given as 30% which, for the assumed price of 180 dollars for the all-valve receiver, corresponds, near enough, to 60 dollars.

7.1 Power Supply from Battery Alone

As the current consumption of a 24" all-transistor receiver from a 12 volt supply is, near enough, 3 amps., a 60 amp.-hour battery, for example, will operate the receiver for 20 hours before it is completely discharged. After this period the battery has to be recharged before it can be used again. If an electrical supply is within reasonable access to the non-electrified area where the television receiver is installed, a practical solution could be to have two batteries of which one is in use while the other is away being charged. It is not easy to assess what the life of a battery will be under these conditions because, although it may be reasonable to assume that the charging of the battery will be carried out by an experienced person, the discharging of the battery may take place without proper supervision. Also, it is not known what damage will take place during transportation. In view of these imponderables, it is considered unwise to assume that each battery will last for more than two years (corresponding to each battery being in actual operation for a total period of twelve months), which means that each year one of the two batteries will have to be replaced. If it is assumed that the average price of a 60 amp.-hour battery is 30 dollars, then the initial battery cost will be 60 dollars and the annual replacement charge will be 30 dollars. To this charge must be added the cost of transporting and charging one battery each week. As neither the distance from the electrified area nor the means of conveyance is known, it is only possible to calculate what the cost of transport must not exceed for this method of supplying power to justify the use of an all-transistor receiver. The calculation can be made as follows :

Initial cost of all-transistor receiver plus batteries : 240 + 60 = 300 dollars.

Saving over all-valve receiver plus petrol engine/alternator = 60 dollars.

Annual charge for power supply by battery alone = $(30 + 52\ x)$ dollars,

where x = transport and charging cost per journey.

Annual charge for engine/alternator supply = 120 dollars.

For these charges to be the same, x = 1.73 dollars.

For a transport cost exceeding 1.73 dollars, the annual charges would start to eat into the 60 dollars initial cost saving, and, for example, for a cost per journey of 3 dollars, the saving would disappear after one year. On the other hand, for a cost of 1 dollar a week, there would be, in addition to the initial saving of 60 dollars, an annual saving of 38 dollars compared with the all-valve receiver combination.

To make possible subsequent comparisons with the other methods of supplying power to an all-transistor receiver, it will be assumed that the cost per journey is 1.73 dollars, thus making the total annual charge the same as for the all-valve receiver power supply, that is 120 dollars.

It follows that the capacity actually chosen for the battery in a given situation will not necessarily be 60 amp.-hour, but will be decided by the number of viewing hours a week and the frequency with which the charging can be carried out.

When the area under consideration has no access to an electrical supply, a means for charging the battery must be provided as part of the installation. A number of ways in which the charging could be carried out are discussed in the following sub-sections.

7.1.1 Use of battery charging set - normal charge

The standard type of charging set consists of a dynamo driven by a petrol engine. The rating of the dynamo is decided by the capacity of the battery to be charged. For example, for batteries which fall within the car type category,

a 30 amp. hour battery requires 30 watts,
a 60 amp. hour battery requires 60 watts,
and a 90 amp.-hour battery requires 80 watts.

In all cases the charging time for a completely discharged battery under normal charge conditions is about 15 hours. As the discharge current is about 3 amps., the ratio of discharge [illegible] charge time improves as the capacity of the battery [illegible], the ratios being, respectively, about 0.[illegible], [illegible].5 and [illegible]. It follows that the charging of a [illegible] amp. hour battery will use, per annum, a petrol engine/generator for one half of the time required to operate an all-valve receiver. As the engine/generator will have to provide a steady charging current for long periods, it would be advisable to have a petrol engine of capacity no smaller than that provided for the all-valve receiver. Although the dynamo may be a little cheaper than the alternator, there will have to be supplied some additional equipment to ensure that the battery can be neither overcharged nor able to discharge through the dynamo. It will be assumed, therefore, that the complete petrol engine/dynamo set costs the same as the petrol engine/alternator set, that is, 180 dollars. On the other hand, as the former will be used only for half of the time per annum as the latter, the corresponding annual fuel costs and depreciation charges will be halved, that is, 30 dollars for each. Further, as the battery and the charger will be on the same spot, the battery could be charged as frequently as was found convenient. Therefore, it should not be necessary to have two batteries, although it may be advisable to assume that the life of this single battery will not be more than one year because it is not known how carefully the battery will be charged. If the price of a [illegible]0 amp.-hour battery is taken to be 36 dollars, then the total annual charge becomes 96 dollars, which is 24 dollars per annum less than for the all-valve receiver. Since the total initial cost of the all-transistor receiver plus charger plus battery is 240 + 180 + 36 = 456 dollars, which is 96 dollars more than the 360 dollars for the all-valve receiver combination, it will take four years before this difference can be recovered. There are certain advantages to be taken into account in the comparison of the foregoing supply arrangements with those for the all-valve receiver. These are

(1) If the engine/generator were to fail, the receiver could be kept in operation for about two weeks by the battery alone.

(2) As the engine/generator would not be running while the receiver is in operation, it would not be necessary to guard against either electrical interference or noise disturbances created by the petrol engine.

(3) No electrical filtering would be necessary to ensure the stability of the picture.

7.1.2 Use of battery charging set - fast charge

The fast method of battery charging involves supplying the battery initially with a charging current many times higher than the normal charging current and then, after an hour or two, continuing with the normal charging for four hours. In this way the battery can be completely recharged in about six hours. In the case of the 90 amp.-hour battery, therefore, the petrol consumption and the running time would be reduced to about two/fifths of that when the battery is charged normally. Unfortunately, fast charging is not as attractive as this calculation suggests because, since this method of charging requires rather careful control, it is usual to carry it out by means of an equipment specially designed for this purpose costing about 220 dollars. Although this type of equipment is very robust and can be expected to have a life of ten years, a calculation made on the same lines as the one carried out in section 7.1.1 shows that the recovery period would be increased to about eight years.

7.1.3 Use of pedal generator

During the last war, in those situations where neither fuel nor normal battery charging facilities were available, a pedal generator provided a method for charging batteries and for operating small transmitters.

Fig. 2 shows a photograph of one of these pedal generators. In this machine the revolutions of the pedals are stepped up by suitable gearing to rotate a dynamo [illegible] 12 volts, thus supplying sufficient power to charge a 30 amp.-hour battery. In the case of the television receiver, the method of operation would be to run the receiver from a 30 amp.-hour battery for one session and then to recharge it before the next session. The time taken to charge the battery would be approximately the same as the duration of the session. Possibly, the pedal generator could be worked by a team of boys, each one pedalling for, say, 30 minutes. It is reasonable to suppose that a pedal generator made in sufficient quantities will not cost more than a motor/generator set, that is 180 dollars. Also it can be expected to be robust enough to have a life of at least ten years. If the price of a 30 amp.-hour battery is assumed to be 20 dollars, the total initial cost will be 440 dollars, which is 80 dollars more than the all-valve receiver combination. If, as before, the battery life is taken to be one year, the annual charges will be 38 dollars plus the payment made to the boys. Here again, as in the case of the transport costs dealt with in section 7.1, it is only possible to calculate what the payment should not exceed for this method to compare at all favourably with the all-valve combination whose annual charge is 120 dollars. For example, for a payment of 8 cents an hour, and an annual viewing period of 750 hours, the total annual charge would be 38 + 60 = 98 dollars. This would mean that it would take about four years before the 80 dollars difference in initial cost could be recovered. It follows that any payment beyond 8 cents an hour would make the use of the pedal generator increasingly less attractive.

For the purpose of making subsequent comparisons, it will be assumed that the payment is 8 cents an hour.

7.2 Power Supply from Combination of Battery and Driven Generator

After the examination of a number of ways in which either a driven generator or a battery could be used separately, there remain to be considered possible combinations of a driven generator and a battery.

When a battery is used in combination with a generator it is said to be "floating" while the receiver is in operation, and in the ideal situation there is complete balance between the charging and discharging currents. In practice, however, there is a possibility of the battery becoming overcharged, and arrangements have to be made to limit the charging current when the battery reaches a charged condition. This situation can also arise if the generator is able to charge the battery when the receiver is not in operation.

A further precaution which has to be taken is to prevent the possibility of the battery discharging itself through the generator if the prime mover stops.

As the power required from the generator does not have to exceed the power consumption of the receiver, a 50 watt output should be adequate. The capacity of the battery should be sufficient to maintain the receiver supply during periods of possible failure of the generator output, otherwise it can be as small as is consistent with robustness and reasonable life.

As the receiver would not be completely dependent on the driven generator for its operation, it is possible to visualise, in addition to a generator which can function continuously while the receiver is working, one which may have to be discontinuous in its operation.

The two possibilities are examined separately below.

7.2.1 Continuously driven generator

Fundamentally, the operation of the charging set discussed in section 7.1.1 is the same whether the battery is being charged or floated. In fact, the only difference is that, whereas the time for which the petrol engine would have to function can be made less than the operating time of the receiver when a battery of the appropriate capacity is charged separately, the times would be the same when the battery is floating because current will be taken from it all the time the receiver is in operation. As a result, the petrol consumption and the annual charges would be no less than those given in section 7.0 for the case when the receiver obtains its power supply from an alternator operating alone. The method, therefore, would be slightly less favourable economically than when there is no floating battery. It has one possible advantage in that, even with a 50 amp.-hour battery, the receiver could be operated by the battery alone for a few days if the petrol engine failed. Also, in comparison with the life of a battery which undergoes a charging and discharging cycle, the life of a floating battery should be relatively long, perhaps four years. This is because

(a) There is much less danger of the floating battery being mishandled,

(b) Even under normal operating conditions, floating a battery increases its life compared with cycle operation.

7.2.2 <u>Non-continuously driven generator</u>

A form of driven generator which cannot always function continuously is the wind-driven one.* Such generators are still used for lighting and battery charging in a few situations where access to a main electricity supply is not possible. The chief disadvantage is that such a generator does not provide any power until the wind velocity exceeds a certain minimum value determined by the design. It follows that the lower this value can be made the more effective the wind-driven generator becomes. For powers of the order of 50 watts the normal practice is to have a wind-driven dynamo which starts to charge the battery when the wind speeds exceed about 11 m.p.h. This comparatively high minimum velocity is due to the fact that, owing to the absence of suitable permanent magnet steels,⊕ electro-magnets are used for the poles. As a result, the necessary exciting current for the dynamo is an important source of loss. It is possible, however, to design a small alternator with permanent-magnet poles, and some preliminary investigations which have been made indicate the possibility of designing a wind-driven alternator which will start to charge a

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* The water-driven generator is not discussed because its possible use as a means of supplying power to a television receiver is regarded as somewhat limited. In any case, basically, it operates in the same way as a wind-driven generator.

⊕ Recent experiments with ferroxdure could change this situation.

battery when the wind speed exceeds about 4 m.p.h. In Fig. 3 are shown two curves corresponding, respectively, to the results obtained with a normal type of wind-driven dynamo and with a model using an alternator. These curves show clearly the improvement in performance achieved when the velocity is low by replacing the dynamo with an alternator.

The output of the alternator would be rectified to obtain the necessary direct current for the floating of the battery.

It is normal practice to fit a wind-driven generator with a governor which automatically controls the generator output and enables the plant to run at normal outputs in winds of high velocity.

The wind-driven alternator would be mounted on a mast having a height dependent on the local wind conditions. A normal average height could be expected to be 25/30 feet. There might not normally be complete freedom of choice for the siting of the mast because, if the distance between the generator and the battery is very long, the loss of power in the cable connecting them can become excessive.

It is estimated that, for reasonable quantities, the cost of the wind-driven alternator, including mast and installation, would be about 360 dollars. Although this is about twice the cost of a petrol engine/dynamo, there is the fact that the life of the installation should be at least ten years, during which period there need be no other maintenance than the regreasing of the bearings.

It would be an advantage for the wind-driven generator to be connected permanently to a 90 amp.-hour battery because, even by itself, such a battery would be capable of operating the television receiver for about 30 hours. This would mean that, even if wind velocities above the minimum were not achieved for a continuous period of about two weeks, viewing could still take place.

As the battery would probably be floating for a large part of its life, it is reasonable to expect a life of at least twice as long as when it is being alternately charged and discharged. If, therefore, two years is taken as the battery life, the annual charge for the battery would become 18 dollars.

The economics of the wind-driven generator method of supply for the all-transistor receiver as compared with those of the all-valve receiver combination can be evaluated as follows. The initial cost of the former (made up of receiver plus generator plus battery) is 636 dollars, which is 276 dollars more than the all-valve combination. The annual charges, based on a ten year's life for the generator and a two year's life for the battery, will be 34 dollars, giving a saving of 66 dollars per annum over the all valve combination. In four years, therefore, the additional cost of the wind-driven generator power supply method would be recovered. The great advantage of this method of obtaining power compared with the petrol engine/generator is that no fuel is required and the maintenance is negligible. Although a petrol engine of sufficient capacity will drive a generator satisfactorily enough to meet the various requirements discussed in the foregoing, it will only do so if it is properly maintained and handled. A wind-driven generator, on the other hand, once installed can be left alone for many years.

In situations where, in addition to the wind-driven generator being the only way of obtaining power, there is a likelihood of very long periods of windless days, it should be possible to guard against this by having a pedal generator of the type described in section 7.1.3 as a stand-by. If such situations are considered to be at all likely, it would be worth while to explore whether, as in the case of the wind generator, the use of an alternator can result in a more effective pedal generator than when a dynamo is used. There is no point in evaluating the costs involved in having the pedal generator as a stand-by because it is assumed that this measure would be taken only when there was no alternative.

8.0 CHOICE OF POWER SUPPLY

In the foregoing, nine possible methods of supplying power to a television receiver in a non-electrified area have been examined. For convenience, these methods are listed in Table 3.

Of these methods, the first is the only practical one with an all-valve receiver whereas the following eight are possible with an all-transistor receiver. It does not follow, however, that, in any given region, all the eight methods can be used. In fact, the actual number depends on how many of the following conditions can be satisfied.

(1) Possibility of access to an electric supply for battery charging.

(2) Availability of petrol and oil.

(3) Existence of winds of adequate speed.

(4) Ability to maintain a petrol engine.

(5) Ability to charge and maintain a battery locally.

(6) Ability to maintain a floating battery.

Table 3

Method	Section Reference	Description
1	6.0	Petrol engine/alternator for use with all-valve receiver.
2	7.0	Petrol engine/alternator for use with all-transistor receiver.
3	7.1	Battery alone - charging by transport to electrified area.
4	7.1.1	Battery alone - charging by local petrol engine/dynamo using normal charging.
5	7.1.2	Battery alone - charging by local petrol engine/dynamo using fast charging.
6	7.2.1	Petrol engine/dynamo plus floating battery.
7	7.1.3	Battery alone - charged by pedal generator.
8	7.2.2	Wind driven generator plus floating battery.
9	7.2.2	As method 8 with pedal generator as stand-by

In Table 4 there is shown, by the presence of an "X", methods which become available when each of the above conditions can be satisfied. It follows that the method so indicated is not usable when the corresponding condition cannot be satisfied.

For example, in order to use method No. 4 it is necessary (a) to have available petrol and oil, (b) to be able to maintain a petrol engine and (c) to be able to charge and maintain a battery.

<u>Table 4</u>

Condition	Method								
	1	2	3	4	5	6	7	8	9
Access to electricity supply			X						
Availability of petrol and oil	X	X		X	X	X			
Existence of winds								X	
Ability to maintain petrol engine	X	X		X	X	X			
Ability to charge battery locally				X	X		X		X
Ability to maintain a floating battery						X		X	X

If, in a given region, the skills required to make use of either a battery or a petrol engine are not available, it must be accepted that none of the methods listed above is a possibility. For such regions, therefore, it would be essential to find new methods requiring very little, if any, skill to operate them. There is a possibility that some (if not all) of the very advanced methods mentioned at the end of section 5.0 could satisfy this requirement; because, in order to function satisfactorily in a space vehicle, they have to supply power for long periods without requiring any attention. The question is whether any of these methods could ever be realised in forms usable in the regions of the type under consideration.

Another possible approach to this problem could be to consider the development of some form of primary battery capable of providing the necessary power at a cost which would not be prohibitive.

It should be mentioned that OCORA [x] is exploring possibilities on the lines indicated above for the supply of power to television receivers in those regions of Africa with which it is concerned.

For those regions where the necessary skills are available, it is assumed that, once the possible methods have been established from Table 4, the minimum complexity at the lowest possible cost will determine which of them is chosen.

It has been pointed out that, in order to make comparisons between the different methods possible, assumptions have had to be made regarding the costs of the various items involved. These costs, all of which appear in the foregoing sections, are gathered together in Table 5. For each item there are given, where applicable, the initial cost, the annual running expenses and the annual depreciation charges. All the values are given in dollars.

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x Office De Coopération Radiophonique, Paris.

Table 5

Item	Initial Costs	Annual Running Expenses	Annual Depreciation Charges
Battery transport	----	90	---
Pedalling labour	----	60	---
Petrol engine/ generator	180	60	60
Wind-driven generator	360	---	36
Pedal generator	180	---	18
Quick charger	220	---	22
90 amp.-hr. battery	36	----	36 or 18 *
60 amp.-hr. battery	30	---	30
10 amp.-hr. battery	20	----	20 or 5 *

* Depending on expected life of battery.

From the values given in Table 5, the total annual charges corresponding to each of the nine methods listed in Table 3 have already been evaluated in the foregoing. These charges are shown in Table 6 together with the total initial cost of each method (i.e., cost of power supply equipment plus cost of television receiver). In order to provide a basis for a comparison of the costs of the different methods there is given, under the heading "Differences", the difference between (a) the annual charges and (b) the initial costs of each of the methods Nos. 2 to 9 and the corresponding values of method No. 1. All the values are in dollars.

Table 6

Method	Total Initial Costs	Total Annual Charges	Differences	
			Initial Costs	Annual Charges
1	360	120	0	0
2	420	120	60	0
3	300	120	-60	0
4	456	96	96	-24
5	676	82	316	-38
6	440	125	80	5
7	440	98	80	-22
8	636	54	276	-66
9	816	---	456	---

From Table 6, the following conclusions can be drawn regarding the economics of each method compared with method No. 1.

(1) The cheapest method is probably No. 3 because, even if the annual charges are assumed to be not less than for the all-valve receiver, it will still take more than five years before any one of the other methods can become as cheap.

(2) The next cheapest methods are Nos. 4, 7 and 8 because, in each case, the additional initial cost can be recovered in four years.

(3) Of the remaining three methods, No. 6 is the most

expensive, No. 2 is the next and No. 5 is the third.

In terms of complexity, for the reasons stated, the following order of preference for the power supply method can be given :-

(1) Method No. 3, because the power supply consists only of a battery which is charged regularly by, presumably, a responsible person in the electrified area.

(2) Method No. 8, because, once installed, the combination of battery and wind-driven generator should operate satisfactorily without requiring more skill than is necessary to add distilled water to a battery regularly and to grease some bearings occasionally.

(3) Method No. 7, because the only skill required is the ability to maintain a battery and keep it properly charged.

(4) Method No. 4, because if the skill is available for (a) maintaining and charging a battery and (b) maintaining a petrol engine/dynamo set, the operation of the television receiver is not entirely dependent on the functioning of the petrol engine.

(5) Method No. 1 or No. 2, because if there is the skill available to make sure that the petrol engine/alternator set functions satisfactorily at all times when the television receiver is required, there is no need

to have the added complication of a battery.

Taken together, the above two sets of conclusions indicate the following order of preference in choosing the power supply method :-

(1) If access to an electrified system is available then an all-transistor receiver supplied by an appropriate battery gives the best answer. The assumption made is that the cost of transporting the battery to the charging point and back will be not more than about 1.70 dollars. If this cost is exceeded by much more than 50 cents, there is the possibility that, after a year or two, this method will become increasingly more expensive than methods Nos. 4, 7 and 8.

(2) If access to an electrified area is not available then, if reliance can be placed on having winds of the requisite velocity during most of the year, the use of a wind-driven alternator together with a floating battery of 90 amp.-hour capacity will give the best answer provided that a period of four years for the recovery of the additional initial costs is not considered to be too long.

(3) If neither (1) nor (2) is possible but a four-year recovery period is acceptable, then the use of a 90 amp.-hour battery which is charged locally by a petrol engine/dynamo set is probably the best choice.

This assumes both the availability of fuel and the ability to maintain a petrol engine.

(4) If neither (1) nor (2) is possible and a four-year recovery period is not acceptable, then the use of a petrol engine/alternator, provided that both the necessary skill and fuel are available, is probably the correct choice. It is assumed that whether an all-valve or an all-transistor receiver is used will be decided by such considerations as cost and desirability of having uniformity with other television receivers in the country concerned.

(5) If neither (1) nor (2) is possible, and a petrol engine cannot be used because of either maintenance or fuel difficulties, then the only remaining possibilities are either (a) a wind-driven generator and a floating 90 amp.-hour battery together with a pedal generator as a stand-by or (b) a pedal generator alone used for charging a 90 amp.-hour battery. The last method has not been included earlier because, unless it is known whether the necessary pedalling labour can be obtained at a cost of about 8 cents an hour, it is not possible to place it in the order of preference. If labour can be obtained at a cost of no more than 8 cents an hour, then the pedal generator method could come after the wind-driven generator in the order of preference.

A summary of the foregoing conclusions in the order of preference is given in Table 7.

Table 7

Order of Preference	Description of Method	Requirements
1	Battery alone - charging by transport to an electrified area.	Shipment to an electrified area for transport (plus charging) cost not exceeding about 1.70 dollars.
2	Wind-driven generator plus floating battery.	(a) Winds of requisite velocity during most of the year. (b) Acceptance of a four-year period for recovery of additional initial costs.
3	Battery alone - charging by local petrol engine/dynamo.	(a) Availability of fuel. (b) Ability to maintain petrol engine. (c) Acceptance of four-year recovery period.
4	Petrol engine/alternator alone.	(a) Availability of fuel. (c) Ability to maintain a petrol engine.
5	Wind-driven generator/battery plus pedal generator as stand-by.	Preferences Nos. 1 - 4 not possible.
Possibly 2/3	Battery alone - charging by pedal generator.	Pedalling labour available at about 8 cents an hour.

9.0 LARGER COMMUNITIES

Table 1 shows that a 25" tube can accommodate a community of about 180 people for general viewing and 35 for educational viewing. For a community larger than this number either a larger viewing area must be provided or more individual receivers must be used.

The largest tube size normally fitted to a standard type of television receiver is 27" which, in accordance with previous calculations, would cater for an audience of just over 200 people for general viewing or 40 for educational viewing. For larger audiences, it would be necessary to provide a viewing surface which is no longer the face of a picture tube but a separate screen mounted at an appropriate distance from a television projector which is used to "throw" the picture on to the screen. By this method, it is possible to obtain pictures up to about 1,000 square feet in area.

A projection system, however, is not considered to be suitable for the areas with which this report is concerned for the following reasons :-

(1) Compared with the domestic type of television receiver, the projection type would be much more difficult to operate, maintain and service.

(2) For a given size of community, the projection type would, in all probability, be more expensive to buy than a corresponding number of individual 23" receivers.

(3) Whereas the number of individual receivers put into use could be adapted to the size of the audience, a projection type of receiver would have to be in full operation even when the size of the audience was comparatively small.

(4) In the case of the projection type of receiver, the failure of this one receiver would deprive the entire community of its television.

It follows also from the above that the larger communities would be better served by the provision of an appropriate number of individual receivers than by the use of a single projection type of receiver. As the cost of a 27" type of receiver is relatively high compared with the cost of a 23" receiver for the additional number of viewers accommodated, it is suggested that all estimates of the number of receivers required should be based on the latter. Although the current price of a 25" receiver makes it also relatively more expensive than a 23" receiver, this situation could change if, as seems possible in the future, the 25" size were to become the more popular one in industrialised areas.

With regard to the number of receivers required for a given size of community, as it would normally be difficult to split up a large audience into separate groups each consisting of 150 viewers (or 50 viewers for educational purposes), it is suggested that when the number of receivers exceeds one, each additional receiver should be assumed to cater for no more than 100 additional viewers when used for general purposes and 20 additional viewers for educational purposes.

One possible variant of the solution using individual receivers should be mentioned. This is to have a complete receiver (the master) feeding signals to a number of individual simpler receivers (slaves). Although each slave need only contain the picture tube and the circuitry necessary for its operation, the slaves would probably be no cheaper than the standard type of 23" receiver if they were manufactured in relatively small quantities. Also the purchasing possibilities would be more restricted. The same disadvantages apply to the master receiver because it would have to be specially designed to work with the slaves. In addition, there would be the disadvantage that the viewing of the whole community would be dependent on the master receiver remaining in operation.

As it can be concluded that, of the three possibilities, the use of an appropriate number of individual standard 23" receivers would provide the best answer for the larger communities, it is necessary to examine whether the order of preference given in Table 7, regarding the choice of the power supply for a single receiver, is changed when the number of receivers is increased. This examination is made in the following section.

9.1 Comparison of Power Supply Methods

In order to provide a basis for the making of subsequent comparisons, the costs of the method corresponding to preference No. 4 are calculated, as a first step, for the case when five 23" all-transistor receivers are in use. As the power required for a 23" all-transistor receiver is about one-fifth of that required for a 23" all-valve receiver, five of the former can be operated from the same petrol engine/alternator as one of the latter. This means that, as far as the power supply alone is concerned, five all-transistor receivers can be operated from a petrol engine/alternator for an initial cost of 180 dollars and a total annual charge of 120 dollars. From what has been said previously in section 7.0 regarding the capacity of the petrol engine, it follows that there would be no reduction in these costs if less than five all-transistor receivers were used.

With these costs in mind, the methods corresponding to preferences Nos. 1 and 2 can be analysed in the following way.

If preference No. 1 is taken first and it is assumed that there are three individual receivers, then the initial cost of the six batteries (three in use and three being transported) will be 180 dollars, which is the same as the amount quoted above. The annual charges will be 3 x 30 = 90 dollars plus the cost of transport and charging. Therefore, to break even with the 120 dollars given above, the transport charges must not exceed 30 dollars per annum, that is, 60 cents a week for the three batteries. This calculation suggests that, even for three receivers, the use of a battery alone for supplying the power should prove to be more expensive than the petrol engine/alternator.

In the case of preference No. 2, it is assumed also that there are three all-transistor receivers in use and that the cost of providing a wind-driven generator to float three 90 amp.-hour batteries remains at 360 dollars. Consequently, the initial cost becomes 360 + (3 x 36) = 468 dollars, which exceeds the corresponding cost for the petrol engine/alternator by 288 dollars. The annual charge becomes 36 + (3 x 18) = 90 dollars. As that is only 30 dollars less than the 120 dollars for the petrol engine/alternator, it will take about nine years before the additional initial costs are recovered. The use of a wind-driven generator would appear, therefore, to compare unfavourably with the petrol engine/alternator even when the number of receivers is only three.

Of the other methods listed in Table 7, preference No. 3 can be dismissed because, if the local petrol engine/dynamo is used to charge more than one 90 amp.-hour battery, the saving in running time disappears. In fact, as each receiver would require its own battery, this method would become increasingly less attractive as the number of receivers increased.

From the foregoing examination, it can be concluded that, with the possible marginal case of two receivers, the cheapest way of supplying power to a number of all-transistor receivers is achieved by using a petrol engine/alternator alone. Of course, as has already been discussed, considerations other than those of economy could decide the final choice.

It now remains to compare the all-transistor receiver with the all-valve receiver when a petrol engine/alternator is used in both cases. It is assumed, in the first place, that five all-valve receivers are used, then the alternator will have to be rated at about 1.5 kW. and the petrol engine will have to be rated at about 3 b.h.p. It is estimated that such a combination will cost about twice as much as the one used for the single all-valve receiver, that is 360 dollars. Also the petrol consumption will be about twice as much, thus costing annually about 120 dollars. The total annual charge (assuming, as before, a life of three years for the petrol engine) becomes 120 + 120 = 240 dollars. As each all-transistor receiver costs 60 dollars more than the all-valve receiver, the total initial cost for the all-transistor receiver combination will be 120 dollars more than for the all-valve receiver combination. On the other hand, as the saving in the annual charge will also be 120 dollars, the additional initial cost will be recovered in one year. Therefore, when there are five receivers in use, an all-transistor receiver should provide a better answer than the all-valve one. For less than this number, however, the all-transistor receiver can become increasingly less attractive financially as the number is reduced.

9.2 Choice of Power Supply and Receiver Type

The conclusions to be drawn from the foregoing examination can be summarised as follows :-

(1) If there are no difficulties preventing the use of a petrol engine, the possibility of achieving a cheaper answer by using all-valve instead of all-transistor receivers exists only when the number of receivers in use is less than five. For less than five receivers, the all-valve receivers can provide an increasingly cheaper answer as the number becomes smaller, the reduction depending on the cost and petrol consumption of the corresponding petrol engine/alternator.

(2) If all-transistor receivers are used, a petrol engine/alternator operating alone will provide the cheapest solution, except possibly for a quantity of two. If a petrol engine cannot be used, the choice lies between having either batteries alone or batteries floated by a wind-driven generator.

(3) In deciding which method to choose when there are only two all-transistor receivers, the following modifications should be taken into account in any comparisons made with the costs of the petrol engine/alternator.

(a) In preference No. 1 the total transport (plus charging) cost becomes 1.2 dollars.

(b) In preference No. 2 the recovery period becomes six years.

10.0 AERIAL AND INSTALLATION COSTS

In the complete installation there will be, in addition to the power supply and the television receiver, the aerial system. Also, in addition to the cost of the items themselves, the total initial expenditure will have to include the cost of both installing them and connecting electrically the receiver to the aerial and to the power supply.

The cost of the aerial system, for a given frequency band, will be decided largely by the strength of the signals received in the area in question. If these signals are weak, an elaborate aerial arrangement mounted on a mast,* 25/30 ft. high (or even higher), would be necessary, whereas, in an area of strong signals, a comparatively simple aerial mounted on a pole about 15 ft. high should be adequate. In any case, the aerial should be installed as near to the receiver as possible to avoid excessive losses in the cable connecting them. If more than one receiver is to be used, suitable coupling devices will have to be inserted between the receiver aerial input terminals to make it possible for one aerial to feed all the receivers.

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* If a wind-driven generator is used, its mast could also support an aerial.

As far as the installation of the power supply and its connections to the receiver (or receivers) are concerned, the cheapest and simplest case is when a battery alone is used. This battery should be placed as near to its receiver as possible to minimise the voltage drop in the connecting leads. In the case of the wind-driven generator the possible danger of having too large a separation between this and the receiver has already been mentioned. Also, the associated floating battery, as in the case of the battery used alone, should be as near to its receiver as possible. The cost of installing a wind-driven generator does not have to be considered as a separate item because this has been included in the price already quoted in section 7.2.2. When a petrol engine/alternator alone is used, it will have to be installed as far away from the receiver as is necessary to avoid disturbing the viewers by the noise of the engine. If the engine is very noisy, it may even be necessary to erect some form of simple sound barrier to avoid having too long a length of cable between the alternator and the receiver. Further, in the case of the all-transistor receiver, particularly when more than one is used, it may be necessary to reduce the power losses in the connecting cable by having an alternator with an output voltage of 240 volts (as for the all-valve receiver) and installing near to the receiver a transformer with the associated rectifiers required to provide a direct current of 12 volts.

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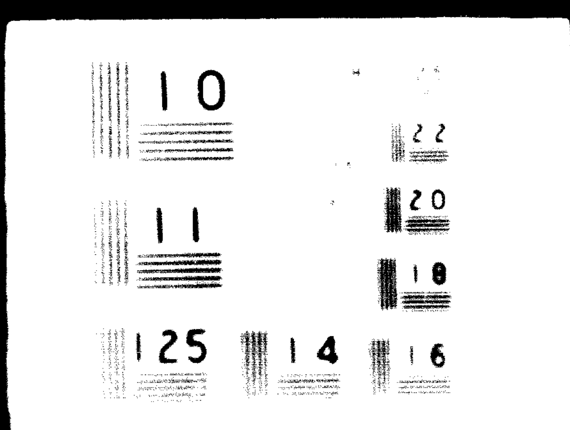


It follows from the above that, as the cost of the aerial system will be decided by the strength of the signals received, and the cost of installing the items involved and connecting them together will depend on the method used for the power supply, it is not possible to give an estimate of these costs which will hold for all areas.

A reasonable guess is that, when one receiver is used, the cost should not exceed 180 dollars. For more than one receiver, an additional cost of 15 dollars maximum per receiver should be sufficient.

11.0 MAINTENANCE AND SERVICING

Sooner or later each of the items comprising the complete installation will develop a fault which will have to be rectified. However, this does not mean that all the items need regular maintenance to remain in operation. For example, a television receiver will normally operate satisfactorily with the minimum of attention, whereas a petrol engine, if it is not regularly cleaned, decarbonised and given a change of oil, will soon break down.

In industrialised countries, maintenance and servicing are not regarded as serious problems because the necessary skilled personnel are usually available. In the areas with which this report is concerned, however, such personnel may be many miles away from the installation and, probably, not easy to contact when a fault occurs. There is, therefore, the possibility of having long periods when the installation is out of action. In order to minimize this possibility, it is suggested that the power supply and the receiver be inspected at regular intervals by a service man from the nearest source. This will ensure that (a) actual faults are regularly rectified and (b) the installation is kept in good running order. In areas where a petrol engine is used, it may be necessary to arrange for quarterly visits; in other cases one visit every six months could be sufficient. In addition, it will be necessary to train a few people in the area itself to handle correctly the various items involved, particularly the receiver and, when used, the petrol engine.

Whether the receiver is all valve or all transistor will make no difference to the way in which it has to be handled. In fact, the only difference between the two types of receiver is that, in the long run, the all-transistor receiver could prove to be the more reliable, but so far there has not been sufficient experience to prove this.

[illegible] MANUFACTURING POSSIBILITIES

As none of the items discussed in this report is of a type demanding manufacturing skills not already available in some of the developing countries, there is no reason why the assembly, if not the complete fabrication, of these items could not be undertaken in such countries. In fact, in a number of developing countries there are today factories producing complete all-valve television receivers and all-transistor radio receivers. It is, therefore, reasonable to expect that in due course they could manufacture all-transistor television receivers. Since certain developing countries are also manufacturing petrol engines, generators and batteries, the provision of television in the areas under discussion should, at the same time, provide work for the factories of the countries involved. It is also possible that, in those developing countries which have no manufacturing facilities today, the creation of a demand for television receivers in their non-electrified areas will provide an incentive for the establishment of such facilities.

13.0 CONCLUSIONS

(1) Since there is no reason why the television receiver required for community viewing in a non-electrified area of a developing country should not be of the same basic type as the one used in an industrialized country, it is the provision of the power supply for the receiver which is the special problem to be solved.

(2) The choice of the method employed to supply the power is determined, in the first place, by the type of

receiver to be used. If the receiver is of the all-valve type, the only practical possibility is to use a petrol engine/alternator. On the other hand, when the receiver is of the all-transistor type there is, in addition to the petrol engine/alternator, a number of possibilities involving the use of a battery either alone or in combination with a driven generator.

(3) The analysis made in the report shows that, once the amount of power required is known, the merits of the different possible combinations of power supply and receiver (or receivers) can be assessed by making certain assumptions regarding the initial expenditure and the annual costs for the various items involved.

(4) The amount of power required, for a given type of receiver, is decided by the size of the community to be served. Calculations made show that a single 23" receiver should be sufficient to provide general viewing for about 150 people or educational viewing for about 30 people. For larger audiences, one additional 23" receiver will be necessary for each additional 100 viewers in the first case or 20 additional viewers in the second case. For audiences of less than 150 (or 30 for educational purposes), a single receiver smaller than 23" can be used if it can be justified economically.

(5) When only one receiver is used, a choice of the supply method best suited to the area under consideration can be made from the order of preference given in Table 7.

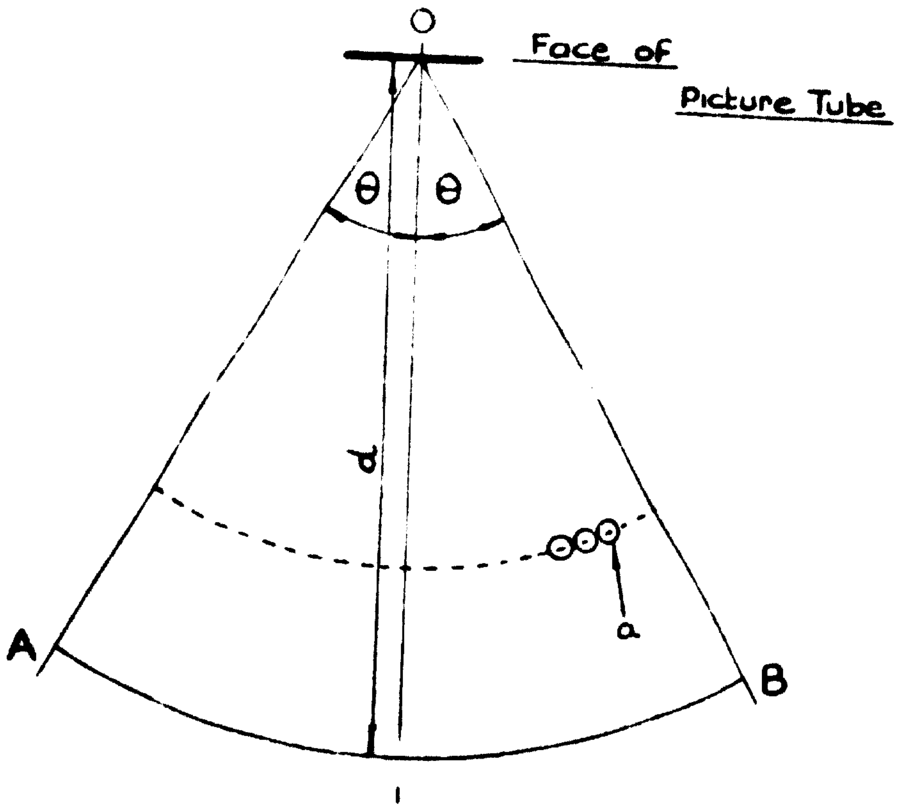
(6) When more than one receiver is used, a different order of preference is established. In this case, the choice of the power supply method can be made from the conclusions given in section 9.[illegible]

(7) To ensure that the installation is kept in good working order, it is essential for regular inspections to be made by a skilled service man.

(8) If there are many areas which have neither fuelling nor battery charging (by access to an electrified area) possibilities, it would be advisable to consider seriously the development of more modern versions of a small wind-driven generator and a pedal generator. In this connection the advantage obtained by using a small alternator has been discussed in section [illegible]. It may also be worth while to examine the possibilities offered by the very recent work which has been done on the design of a flat type D.C. motor using ferroxdure magnets.

(9) In regions where the skills necessary for the operation and maintenance of either a battery or a petrol engine

are not available, none of the methods discussed in the report is usable. For such regions possible solutions might be found from among the devices which have been developed for use in space vehicles. It should at least be worth while to investigate, as a separate task, the possibility of obtaining such solutions. If eventually there emerged a method of supplying power at a reasonable cost requiring very little, if any, skill to operate and maintain, it would probably supersede most, if not all, of the methods examined in the report.



Total Viewing Area = OAB

$$= \pi \times d^2 \times \frac{2\theta}{360}$$

No. of Viewers = $\frac{\text{Total Viewing Area}}{\text{Area per Viewer}}$

$$= \pi \times d^2 \times \frac{\theta}{180} \times \frac{1}{a}$$

FIG 1

Number of Possible Viewers

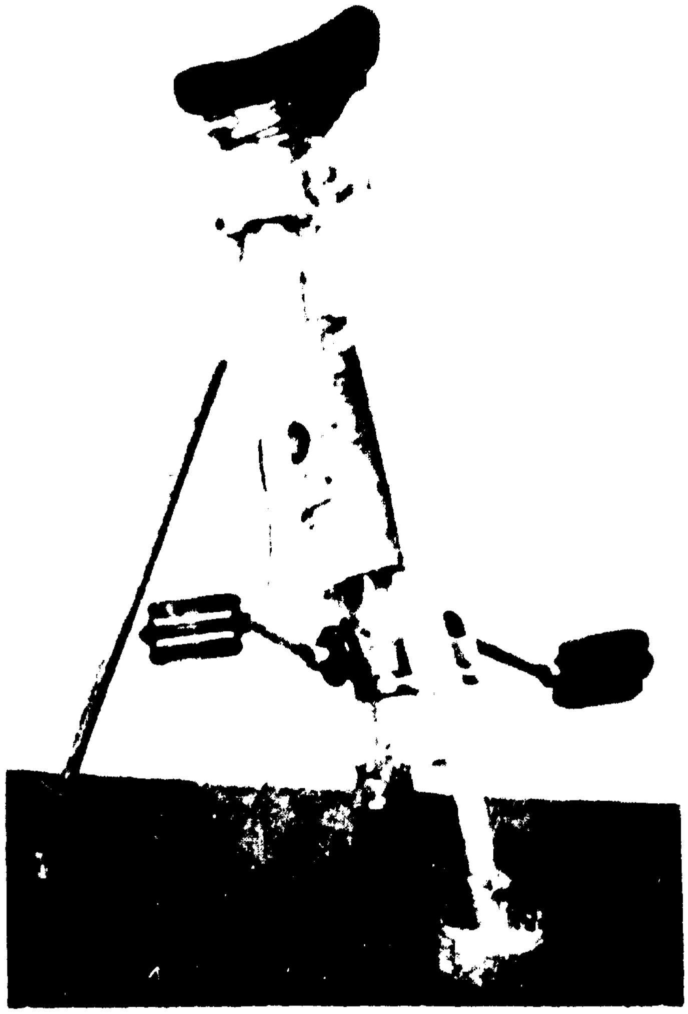


FIG 2

Pedal Generator

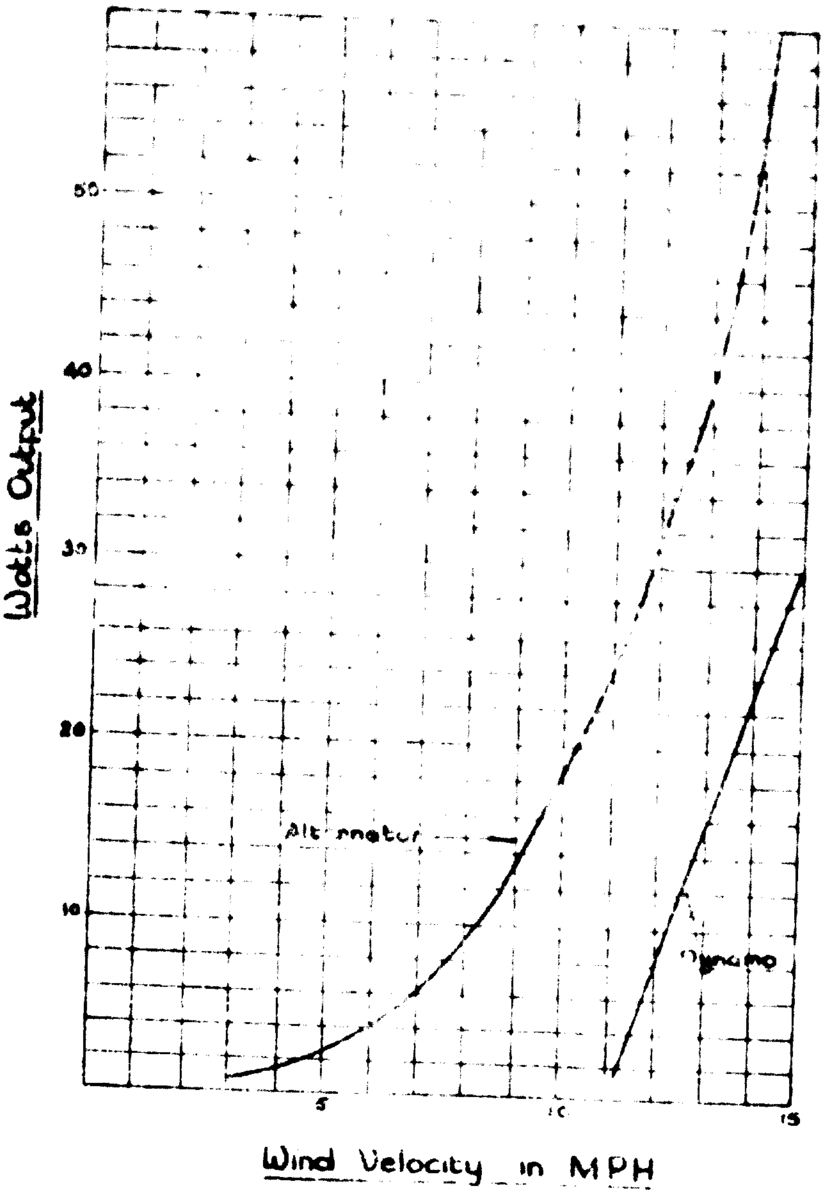


FIG 3

Wind - Driven Generator

Performance Curves

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