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Final Year Dissertation
Private Power Generation at “National Trust Bateman’s”

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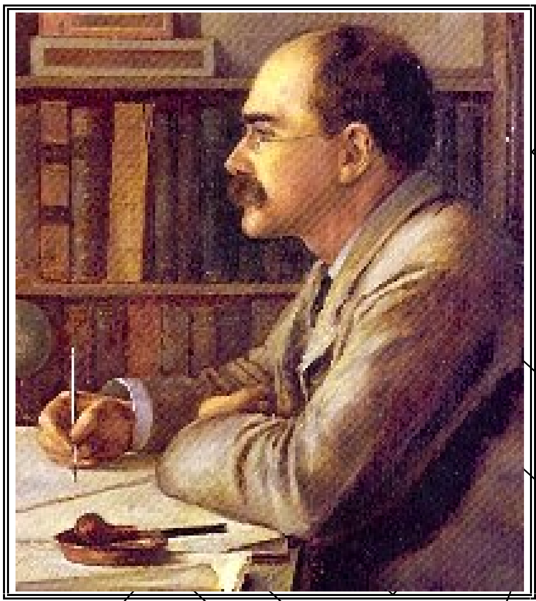

Song of the Dynamo

How do I know what Order brings me into being?
I only know, if you do certain things,
I must become your Hearing and your Seeing;
Also your Strength, to make great wheels go round,
And save your sons from toil, while I am bound!

What do I care how you dispose
The Powers that move me?
I only know that I am one with those
True Powers which rend the firmament above me,
And, harrying earth, would save me at the last-
But that your coward foresight holds me fast!

Rudyard Kipling 1865-1936

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1. Summary

This text begins by discussing whether, due to the increasing use of small scale private power generation in recent years, we can benefit from knowledge gained about similar systems installed years ago in the early days of the electrical supply industry.
In particular the use of alternative sources of energy are considered. It is demonstrated that this is the case, and that we have much to learn for the past.

The text discusses in detail a small hydroelectric generating system installed in 1902 at Bateman's at Burwash in East Sussex, former home of the author & writer Rudyard Kipling.
It is demonstrated that the early generating equipment suffered from many limitations, but that it was economically and practically viable to use such equipment with the small loads required in those days.

Further discussion reveals that modern day application of a similar system would prove impractical due to the limited power available from small hydroelectric schemes. However, the principles of supply and in particular energy storage (by means of batteries) are found to be still relevant in modern installations.

The text continues by noting that with the use of modern day technology such as photovoltaic cells, systems similar in principle to those installed 100 years ago, in all but form of prime mover, could be developed and installed in the future. Such systems would be small scale, economical and above all environmentally friendly.

The text concludes by paying tribute to earlier engineers and craftsmen.

The text is fully referenced and a bibliography is included for further reading.

2. Introduction

The use of electricity as a means of power has long been taken for granted in the UK. It is however, easy to forget that the public supply systems that we nowadays take for granted have not always been available.

It is also a fact that although electricity is in itself a clean source of energy, it is mostly generated by means of burning fossil fuels and hence electricity generation contributes greatly to carbon dioxide (CO_2) emissions. This environmental impact, together with the expense of public electricity and recent falls in reliability of public supplies[i] lead us to consider what alternative means exist to supply electricity on a private basis.

The privatisation and deregulation of the electrical supply industry[ii] has had impacts beyond the change to the name at the top of an electricity bill. The whole basis of supply has changed from one of unlimited capacity being available at any time, to situation where generation is matched closely to demand. Hence, there is no spare capacity, this can affect the quality and reliability of the supply.

It is partly due to the above that private generation of various types is becoming once again popular. We may consider this a relatively new facility, but before about 1920, it was the norm for electricity to be generated privately and independently. This is because public supplies were simply not available before this time.
Logically then, before public supplies were available, our predecessors were faced with similar problems to ourselves ie:- can we generate electricity ourselves?, can we do it economically? and can we generate enough? [1]

An attempt at applying old methods to modern problems often proves unrealistic due to basic changes in technology and expectations. However, are modern problems really new? If not, what means were taken to overcome old problems in the past?
Likewise, an old problem, hard to solve in the past, may benefit from the use of modern thinking and technology.

By way of illustration of the above, and as comparison to our high tech modern day systems, a private generation system installed at the turn of the century, typical of such installations of the time, is described and discussed later on in this text.
We will then investigate whether modern technology holds the answer to limitations experienced at the time. If not, are there other options?.

This text is obviously largely documentary, however, it is considered that the application of a engineering approach to an historical situation, usually the sole domain of historians provides some interesting insights.

[i] It is perceived by some that the interruptions have increased following privatisation. Also that voltage and supply stability have deteriorated.
[ii] Implemented during the 1980s firstly the 1983 Energy Act then the 1989 Electricity Act

3. Private Power Generation - Methods & Principles

In order to sensibly proceed in any study of a private generation system, it is necessary to briefly investigate the principles and methods by which electricity can be generated. Understanding such basics enables the reader to fully appreciate reasons and limitations associated with the systems in question.

We are all familiar with the large power generating stations situated throughout the country. These stations supply electricity for national use.
In the UK these stations are generally fuelled by one of the following main sources of fuel.

1. Natural Gas - Derived from the North Sea, natural gas (methane) is used to generate approximately 16% of our national power generation capacity[2]
2. Oil - Commonly used in the 1970s Heavy grade oil is derived from the North Sea fields and imported. Oil fuels approximately 2% of our national power generation capacity.
3. Coal - Good quality coal is nowadays imported although some British coal is still used. Coal is the major contributor to power generation, contributing to approximately 56% of national power generation capacity.
4. Nuclear - Varieties of technological methods are used to generate electricity from various radioactive elements. An major contributor, nuclear power is used to produce approximately 16% of our national power generation capacity.

The above supply the majority of our electrical needs. The contribution of such large generation plants is approximately 94% of the total national electricity usage.

In addition to the above, several methods of alternative generation are used for public supply.

1. Wind power - Harnessing the energy of the wind, specially design wind turbines grouped together to form "Wind farms".
2. Hydroelectric - Using dammed rivers and watercourses, the potential energy of downward flowing water can be harnessed to generate electricity.
3. Solar Energy - Suitably arranged photovoltaic cells can generate electricity. Other forms of such generation exist but are not used in this country.
4. Geothermal - The internal heat of the earth's mantle can be utilised to generate electricity.

Figure 1 - Alternative energy sources

The above "alternative sources" account for just approximately 6% of the national electricity generation.
When combined, the public generation stations both conventional and alternative produce electrical energy that satisfies approximately 98% of our national electricity usage.

The remaining 2% of electricity used by the UK populace is generated by some form of private generation[i]. That is, generation systems that are owned or run by private individuals or companies.

Private generation can be further divided into various types[3].

1. Base load generation - Where electricity is generated on a private site and used by the owner to serve equipment and plant on site. There is often some facility to export surplus electricity to public supply companies. Such generation is normally due to the commercial and financial reasons. However, remote users may resort to such generation if public supplies are not available.
2. Standby Generation[i] - Where generators are provided to ensure continuity of supply if the public supplies fail[4]. Such systems are normally employed in critical situations such as hospitals or commercial installations where supply failure could endanger life or profits.
3. Temporary Generation - In remote situations where cost or distance may preclude availability of public supplies, self contained generating plant can be installed to serve the required load.

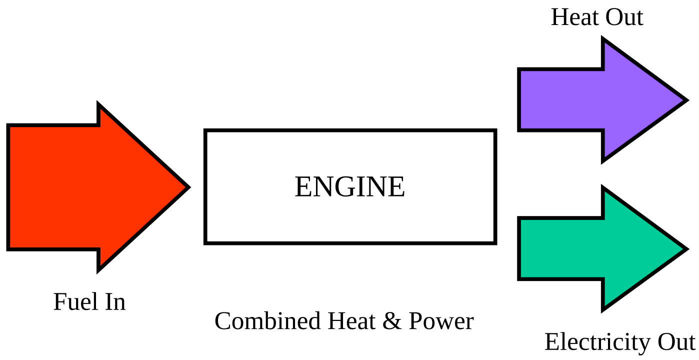

Figure 2 - CHP operation

[i] We have ignored any electricity that is imported. There are cables connecting us to the European mainland that enable us to buy and sell electricity. This can distort figures and so it has been assumed that on average, we buy as much as we sell.

4. Combined Heat & Power - Where heat is required as well as electricity, it can prove effective and economic to operate gas or oil fired engines and recover both high & low grade heat from these for use in heating, hot water generation or other industrial processes. The engines are also used to drive generators which supply some or even all of the installation's electrical requirements. CHP is used in both large and small scale applications.

Private Generation can nowadays incorporate several of the previously detailed methods of generation. However, oil and gas are by far the most common fuels. Coal is expensive to implement in a clean fashion and use of nuclear fuel is limited to nationally licensed bodies.
Hence most schemes utilise some form of fuel burning engine[ii] or turbine[iii] as the prime mover.
It is rare to find alternative forms of energy being used by private individuals or companies (with the exception of wind power being used for boats and/or leisure activities)[iv].

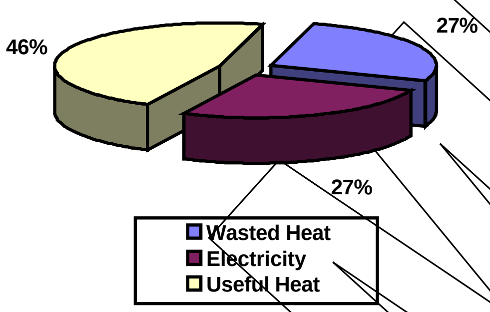

Figure 3 - CHP efficiency[v]

It is clear from the above that private generation is employed mainly for financial or operational reasons rather than for environmental considerations. Whatever the type of private scheme, it usually still produces electricity at a relatively low efficiency (typically 75% for a CHP scheme).
This means that the overall effect of burning fossil fuels on the environment is little changed whether the fuel is burnt by a power station or small private generation plant.
This is a shame, and need it necessarily be so?
It will be seen in the next section that at one time small hydroelectric private generation systems were used to good effect.

In light of recent political developments with regard to the reduction of CO_2 levels[vi], we need to consider whether or not modern installations could be served from environmentally friendly means of generation? In particular, with the recent

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[i] Standby generation is not strictly included in the national output figures noted earlier. It is not used unless needed.
[ii] Such as a modified lorry or car engine
[iii] Turbines fired on gaseous fuel operating in a similar fashion to a jet engine.
[iv] Some experiments are being made in the industry with regards to solar energy. These are discussed later on in the text
[v] Information derived from a typical CHP unit published output data.
[vi] Kioto summit, 1997. An international event held in Japan where the world's increasing energy needs were discussed and targets were set for the reduction of greenhouse gas emissions.

international focus on reducing CO_2 emissions and fuel usage, can alternative means of energy be developed.

4. Private Power Generation - How it used to be at National Trust Bateman's

The previous section described how electricity can be generated. With the exception of some modern methods[i], most of the means to generate electricity were available to users from the earliest days of electricity distribution and usage.

It is often productive to study the past in order to gain an objective view of modern ideas and systems. Thereby we can learn from our predecessors about the problems, limitations that were prevalent in earlier times. Study of the means used to overcome such problems can give us some valuable insights into how modern day systems could be designed and used. More importantly such study can prevent us from trying to "re-invent the wheel"! [ii]

The writer has chosen to detail a typical small scale private generation system, installed about a hundred years ago. The reasons for this being:-

a. To illustrate the above statement and see if we really can learn from the past.
b. To research, collate and describe an historical installation about which little is know
c. To gain knowledge about earlier times and the context against which the system was installed. In particular the relevance of such an installation to an historically important individual, namely Rudyard Kipling.

4.1 *Overview.*

Within the county of Sussex, just outside the village of Burwash, is situated a large country house named Bateman's. The house is set in approx. 33 acres of land and dates back to the seventeenth century (having the date A.D.1634 inscribed over the door) when it is documented[5] that a Wealden Ironmaster took residence. Associated with the house are outbuildings and an old mill set aside a running stream at the bottom of the hill upon which the house is built.

In 1902 Rudyard Kipling and his American wife, Caroline, purchased Bateman's after returning from travels around the world including India where he was born and possibly his most famous work "The Jungle Book" was conceived and written.

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[i] Geothermal, wave power, photovoltaic cells etc..
[ii] By this, it is meant that time and energy may be wasted if a problem has been solved already by others in the past.

Figure 4 - Bateman's

At this time the house had no bathroom, no running water and importantly, no electricity.
The domestic use of electricity at this time was still generally restricted to the very rich, or eccentric. It was becoming common for coal or "coal gas" fired small power stations to be built within towns, but such generation was generally restricted to areas where industrial users were demanding electric current to drive their "modern machinery". Street lighting was commonly installed in such situations but for private houses to have electric lighting was still something of a rarity[6].

Kipling was a keen collector, he was also what would these days be described as a "Technofreak". His travels, enabled through his increasing popularity and family money, had given him insights into the latest developments in technology and popular science that were rife at the end of the Victorian era.

In particular he missed the existence of electric light which has been installed in his immediately preceding residence at Rottingdean, Sussex.
It is therefore no surprise that he immediately set to work to provide electric lighting to his new house which was to remain his residence until his death in 1936.

Bateman's is now owned and maintained by the National Trust, it having been bequeathed to them in 1939 upon the death of Caroline his wife.

The electrical installation that was installed relied upon private power generation for it's electricity supply. No fuel was used, the prime mover being a water driven turbine - environmentally friendly[i] hydroelectric power !

The installation that Kipling commissioned is only partly in evidence, most of the installation having been removed over the years to make way for more modern wiring systems. Also, alterations and extensions to the original system make it hard to differentiate what was original and what is more modern. However, sufficient evidence exists to reconstruct the installation and documentary research has helped to fill in some of the gaps.

Notwithstanding the above, it has been revealed that not all accounts about the installation match each other. Neither has much technical information been recorded about the systems that were installed. The rest of this section describes the installation from both an engineering and historical point of view.

[i] Possible deleterious effects on the environment due to damming were in this case, not relevant as the dam was already present.

It should be remembered that the installation was installed in 1902 - nearly 100years ago. We would expect an unfamiliar installation, but this is not the case and it will be seen that a lot of the methods and equipment used are reassuringly familiar.

The reader will note that measurements and dimensions throughout this section of the text are given in imperial units. This is done on purpose; the majority of references found are in such units, also the equipment when measured, proves to have been designed without metrification in mind! It has hence been decided to use these units throughout to maintain continuity.

4.2 *The System*

Adjacent to the mill at the bottom of the hill about 250 yards from the house was constructed a small enclosure housing a DC dynamo. The dynamo was driven by a water turbine (the prime mover), which in turn was driven by water passing out of the adjacent mill pond (associated with the flour mill which is still in existence).

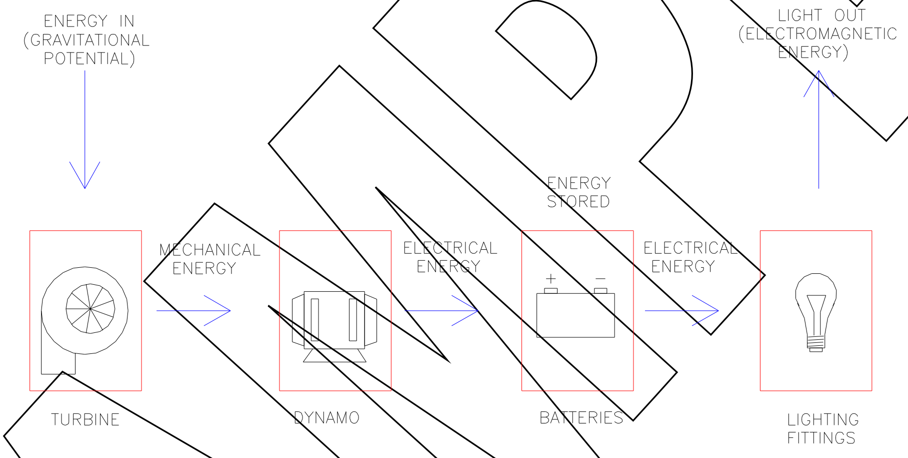


Figure 5 - Block schematic of installation

This small hydroelectric power scheme was used to charge up batteries located adjacent to the house, the electricity supply running to the house via a buried cable. The batteries were in turn connected to the installation within the house which comprised of lighting points only.

The whole system was self contained and served the whole of the electrical needs of the installation. It is reported that the turbine was used to charge up batteries during the day only. Investigation reveals that this is because the mill pond would drain if the turbine ran any longer (discussed later).

It was evidently reliable[i] and operated for many years before the introduction of a main electricity supply from the road (approx. 1927) made the system redundant.

[i] Kipling tells us so in his autobiography

4.3 *Site arrangement..*

The dynamo house is situated immediately adjacent to the old mill, there being a gap of approximately 1.5yards between the mill wall on which a water wheel is located and the edge of the dynamo house. Both are situated immediately next to the ancient but man made mill pond, still full, from which is supplied by two small triburitories to a small river, the River Dudwell, running along the base of the hill. One of the triburitories is called "Puck's Stream" a name that was to be used much in some of Kipling's later written works.

A dam and outfall arrangement is positioned between the dynamo house and the mill.

Figure 6 - Mill pond viewed from behind dynamo house

A small water course takes the "used water" to the Dudwell about 30yards from the mill.
The mill and dynamo house are situated at the base of the main hill leading down from the house.
The old flour mill has been restored in recent years and is open to the public during the summer months.

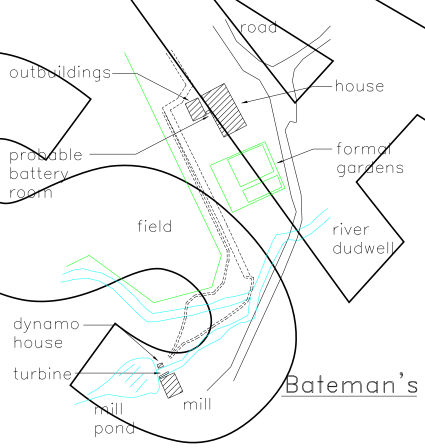


Figure 7 - Site Plan

The house is located further up the hill at a linear distance of approximately 250yards from the mill. The intervening land being a mixture of woodland, pasture and formal gardens nearer the house. It was essentially the same in 1902.

The batteries were housed in an enclosure adjacent to the house (the actual location is discussed later)

4.4 *Prime Mover.*

The prime mover is a cast iron turbine having 14" impeller blades and being of a split flow design[i].

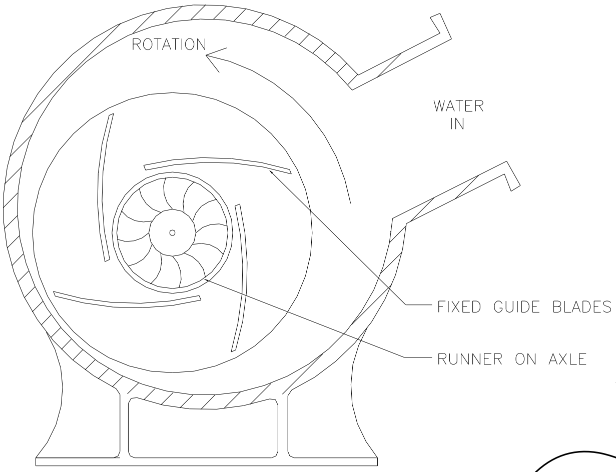


Figure 8 - Vortex turbine

The turbine is capable of delivering 4 hp and will run at 280 rpm. It is driven by water delivered by a 14" pipe from the mill pond above. The water is discharged via two 10" downpipes. The effective "head" of water is 12½ ft even though the turbine is only 8ft below the mill pond, this is due to suction action of the tail race (the tube leaving the turbine) terminating as it does below the "tail water" level 4 ½ ft below the turbine.

Water passes into the turbine from above, is deflected by the fixed blades and passes onto the central 14" Impeller. This "Runner" is fabricated from sheet Brass and is fixed to the cross-mounted axle shaft. The discharge pipes initially surround the shaft on opposite sides of the turbine and then both turn downwards so that the final water flow is vertically down.

Figure 9 - The turbine in situ.

If the head is maintained, water will pass through the turbine at approx. 2000gallons/minute (151 litres/second). Obviously this represents a very high flow rate and in fact to would not continue, as the mill pond water level would be fall below the turbine inlet pipe entrance after just 4 hours.

This type of split flow turbine was invented by James Thomson in 1850 and was patented as the "Vortex Water Wheel".

The unit at Bateman's is the original turbine and was manufactured by Gilbert Gilkes & Co of Kendal.

This company still produce such equipment today although the Batemans' turbine is now long obsolete. Their technical department are able to provide further information about products that were available at the time, although such information retrieval is chargeable.

[i] Water divides around each side of the turbine and discharges down on either side of the unit.

In 1975 the turbine was passed over to the Royal Engineers[i] who refurbished and reinstated it. The turbine is still operational and has since occasionally been demonstrated to visitors.

The turbine drives a shaft which passes through the dynamo house wall. Here a large 36" steel pulley is installed which, via a belt, drives a smaller 6" pulley on the dynamo. The ratio between large to small pulley is approx. 3.7:1.

Applying basic pulley ratio theory means that the dynamo shaft would be driven at:
280rpm x 3.7 = 1036rpm.

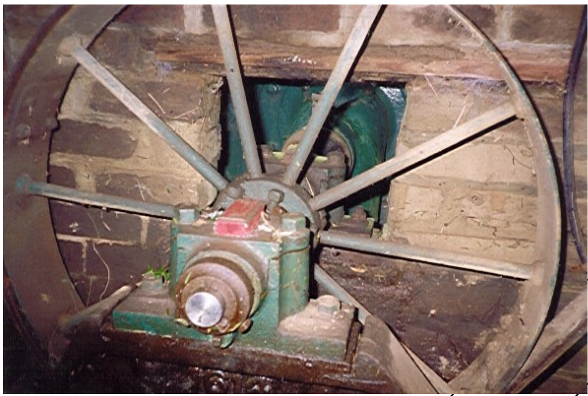


Figure 10 - Diving pulley.

A 15 inch pipe runs from lower down on the millpond retaining dam. This was installed in 1908 and bypasses the turbine altogether. It is termed as an "eduction pipe" and was used to drain the millpool in order to clean the turbine inlet and remove silt and rubbish. The installation of this pipe proved problematic as is described later.

The turbine is put into operation by lifting the "gates" or "shutters" at the mill pond end of the feed pipes.

[i] Photos taken during the refurbishment of the turbine are able to be viewed in the Mill during the house opening season.

4.5 *Dynamo.*

The dynamo is mounted on a concrete pedestal within the dynamo house. The pedestal shows signs of having been altered and partially recast. In fact the whole assembly was raised by approximately 3ft some years after the original installation due to flooding of the Dudwell. Presumably when Kipling commissioned the installation no one told him that the river regularly flooded. From outside it can be seen that the whole dynamo house has been raised at some time. Some later brickwork is present that does not match the original lower courses. It is not clear, but it would appear that this may have been done to facilitate the raised dynamo.

Figure 11- Concrete platform

The dynamo was manufactured by Crompton & Co in 1902. It is, or was at the time, a standard production unit. It is approximately 16 inches in diameter, has a cast iron frame and is mounted on oak timbers cast into the concrete plinth.

The rating plate is still intact and reveals the following information

Crompton & Co Generator
105/150 volts **15 amps**
1000 rpm **Shunt wound**
Continuously rated **Serial No 143327**

Closer inspection reveals that it is fan air cooled and has a case construction similar to modern day drip proof motor.

Figure 12 - The dynamo.

It is a fine machine and still in good condition although it is slightly rusty due to being in a unheated environment.

Reference to old electrical installation books[7&8] reveal that the unit was commonly used for small scale D.C. generation at the turn of the century. The use of equipment manufactured by Crompton & Co was widespread at this time, the company being leaders in the field of electrical rotating machine manufacture.

As will be seen later, the installers of the system had close ties with Crompton & Co.

Whatever the actual popularity of Crompton & Co equipment may have been, most contemporary illustrations shown a Crompton machine

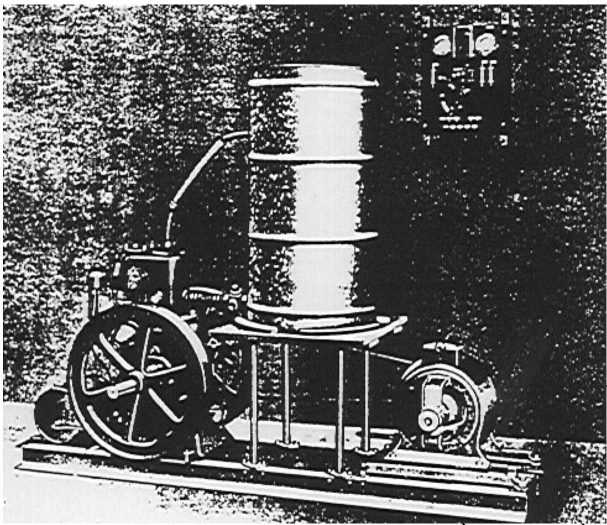


Figure 13 - Contemporary photograph showing a Crompton dynamo[9]

The dynamo output voltage would have fluctuated widely according to the speed at which it was driven, no automatic voltage regulation was available in 1902. This would not have been as bad as it sounds; firstly, as the output was used to charge lead acid accumulators which would to an extent level out the voltage according to their own output (the batteries are discussed in detail later). Secondly, the turbine would only have operated between relatively narrow values of head. Hence the water would fall below the turbine inlet before speed dropped off too far.

4.6 *Switchpanel.*

Adjacent to the dynamo, is situated the original switchpanel that was installed in 1902. Looking itself like something from a history book, it comprises 2no single pole rotary isolators- unconnected, double pole fuses, a manual voltage regulator (rheostat), 2no more recent spade action switches - linked to provide double pole action, an ornate brass nameplate and a space where a brass voltmeter should be (now located elsewhere).

The panel name plate bears the inscription "Christy Bros & Middleton, Electrical Engineers, Chelmsford". The company still exist although much has happened to them since they installed this equipment[i].

The panel was fed from the dynamo via a short length of cable. The original cable has long gone, a short length of PVC twin & earth cable is currently connected.

[i] The history of Christy Bros & Co is discussed briefly in section 4.12

Figure 14 - Front view of switchpanel

The main isolators were connected to the outgoing feed, and provided double pole isolation to the 110Volt DC nominal supply. The contacts are exposed, and it is certain that an unwary individual would have got a sizeable shock if both terminal were touched at once. The isolators are unbranded but again fully reflect contemporary equipment shown in technical books from around the turn of the century.
Note that no incoming isolators were present.

The fuses on the live side of the outgoing isolators are of a bare wire exposed type. They would probably have been rated at 15A to reflect the capacity of the dynamo.

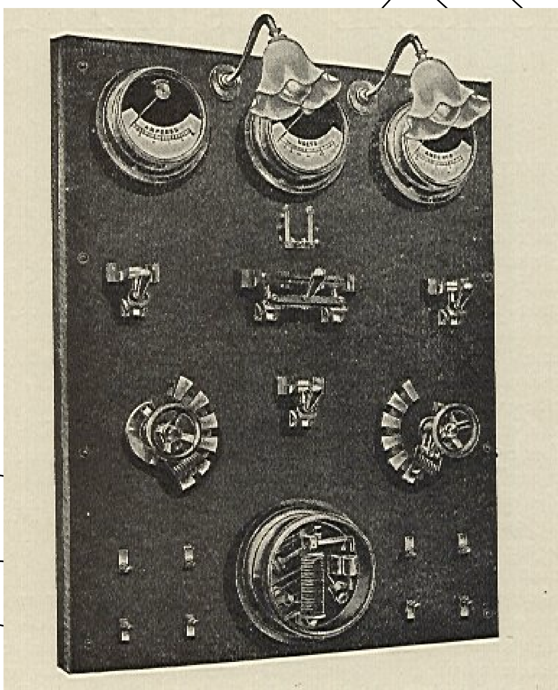


Figure 15 - Contemporary plate of similar switchpanel[10]. Note open isolators.

The voltage regulator is of a manual rotary rheostat type. This unit, connected across the incoming supply would enable a degree of regulation under varying load and of course water conditions. However, this would need to have been done manually with an eye on the actual output voltage.
It is not possible to inspect the actual connections without removing the switchboard from the wall. However, it is probable that the connection arrangements shown in figure 16 would have been employed.

The gap to the top left of the panel was originally filled by a voltmeter, which would have been connected to the outgoing terminals, and used to monitor the regulated voltage. The voltmeter is missing from the panel, but is still in existence, being currently kept safely in the main house. The switchpanel was removed during the turbine refurbishment and photographs taken at the time reveal that the voltmeter was in fact installed at this time. It is not clear why it was removed.

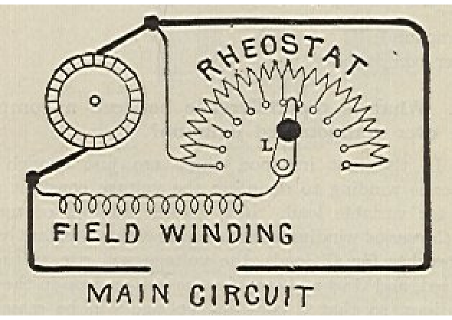


Figure 16 - Connection of regulator[11]

The two central switches, although old, are not contemporary with the switchpanel. They are of a pattern commonly used between the years 1930 and 1940 having porcelain bases, brass screw-on face plates and compact throw-action switch blades inside. They are thought to have been fitted to the panel probably after it was decommissioned, in order to easily switch some assorted items of equipment that are mounted to the side of the dynamo house. This equipment is again old, but far more recent than the dynamo. It was likely installed in the past to demonstrate operation of the dynamo maybe after Kipling's death. It is poorly installed - certainly not of the calibre of Christy Bros & Middleton!. The equipment is linked to the switchpanel by a small flexible conduit[i].

Figure 17 - DIY equipment on wall

Whilst not of particular interest in itself, this old "DIY" equipment board does contain a very old light switch, older than the rest, which dates back to the turn of the century. It is very likely that this switch was originally installed in the main house as part of the original internal lighting installation. In which case it possibly one of the only parts to have survived.

Returning to the main switchpanel, all the equipment is mounted on a hardwood (probably teak) back-plate. The equipment must have looked stunning when first installed, even now it is attractive. Unfortunately condensation is causing the switchpanel to deteriorate and is corroding the steel parts of the assembly.

It will be seen later that such panels were obviously a speciality of Christy Bros & Middleton[ii]. When one studies the panel, it is easy to associate with the individual who first fixed it to the wall. One can easily imagine him stepping back and admiring the fine craftsmanship that went into the production of such equipment. The writer has installed many items of electrical equipment in the past but never such a fine looking panel as this!

[i] This is in fact probably older that might first be apparent. This is discussed in section 4.10
[ii] A similar panel can just be made out in Figure 13.

4.7 *Cable.*

The dynamo house is a long distance from the main house and it is evident that a suitably strong cable was necessary to overcome the tortuous route linking the two buildings.

In fact, an armoured cable was used upon the advice of one of Kipling's acquaintances[i].

This cable can still be seen within the dynamo house. It is now disconnected, but it was originally connected to the outgoing terminals of the switchpanel and can be seen passing through the dynamo house wall from where it runs up to the house.

The cable is an early steel armoured cable. It has two copper conductor cores approximately ¼ inch diameter (~10mm² in modern reckoning), which are insulated by means of rubber with a cloth serving.

The inner cores are bound together by more cloth, the whole of the inner bundle is protected by a steel tape approx. 1 inch wide that wraps spirally along the length of the cable. The whole is protected by an outer layer of jute which was impregnated with pitch.

Kipling's writings[ii] tell us that it is in fact an early marine cable designed for deep sea use and tested at high voltage (1200Volts). This particular length failed under test, somehow Kipling acquired it and had it installed. It can only be assumed that cable was sufficiently intact to withstand the 110Volt DC supply used at Bateman's.

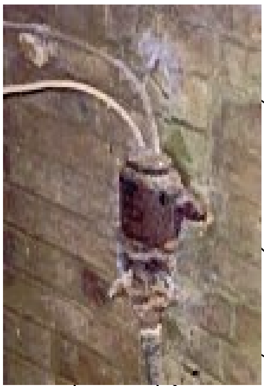


Figure 18 - Cable termination in dynamo room.

The cable is terminated adjacent to the switchpanel in a cast iron pitch filled "head" remarkably similar to modern day cast iron cable service heads. The cores can clearly be seen leaving the pitch where they run loose to the switchpanel. One of the cores still has it's original sweated lug intact.

The exact route of the cable is unknown. However, it surely would have been as straight as possible. In such a case it would breach the river near the mill (probably running along one of the small whears that are still present) and pass through small wooded area. From here it must strike straight up the hill towards the house, probably following a path running alongside the formal gardens.

The rest is guesswork and unless cable locating equipment is used it is impossible to accurately chart the route. However, what is certain is that the cable would have ended up terminating within the battery house, which as will be discussed later is considered to have been attached to the house behind the kitchen and scullery areas.

Within the main house basement, there is an old cable entering from the same side of the building as the assumed battery room. This cable is of the same type and construction as the main cable. However, it is smaller[iii], it is probably the cable that

[i] Sir William Willcocks as noted in Kipling's autobiography.
[ii] Refer to section 4.11
[iii] The main supply cable would have had to been larger to overcome voltdrop over the 250yards.

would have left the battery room (discussed later) and hence would have brought the electrical supply into the house for termination at the main distribution point.

It must be remembered that these were early days in terms of electrical engineering. Nevertheless, the cable and methods of its installation indicate the intense development that had gone on since the dawn of the electrical installation industry, at this time only 20-30 years before.

4.8 *Battery room.*

A National Trust guidebook, now out of print, indicates that a large number of glass batteries were installed in an outbuilding adjacent to the main house. Upon inspection of area surrounding the house and discussion with the current house steward, it is evident that no obvious separate buildings would have suited the purpose.
However, immediately adjacent to the kitchen block, within a small courtyard, as a fair sized brick lean-to structure. This is built with bricks that are very similar to those that were used to build the lower half of the dynamo house. The structure is approximately 8 ft high, 7 ft wide and 4 ft deep. Two hardwood full height doors are installed to the front and the roof would at one time have been waterproof.

Below the structure is a void and some largely redundant drainage pipework. The walls within show signs of having had shelving and brackets installed in the past and importantly, the dimensions are just about right to have had 50 lead acid accumulator cells installed on shelving. The batteries will be discussed later, but it is considered that despite the lack of firm documentary evidence that this is in fact the battery room.

Upon consideration, the evidence is persuasive. The room would have to be this size to enable batteries to be installed whilst maintaining access to the cells. Also, the room would have to have an external aspect or at least be well ventilated, due to the noxious fumes let off by the batteries.

Figure 19 - Probable battery room

Assuming that this structure was indeed the battery house, then the supply cable would have been terminated here, in a fashion similar to that seen in the dynamo house. It is probable that a switchpanel or control board would also have been installed here. This would have been used to operate and control the charging of the batteries.

4.9 *Batteries.*

The fact that batteries were used at Bateman's is beyond dispute. Despite the fact that there are no batteries left at Bateman's, reference to old installation books[12 & 13] indicates that early generation schemes such as the installation at Bateman's relied upon the dynamo output (irrespective of the type of prime mover) charging up some type of rechargeable battery. Hence power would be available even when the dynamo wasn't running. The time limit imposed by the falling level of the mill pond when the turbine was in use would undoubtedly have severely limited the use of the lighting installation.
Also, the batteries would have stabilised the supply voltage, which would have gradually fallen off as the mill pond "head" reduced[i].

Notwithstanding the above reasons, the greatest evidence indicating the use and indeed the type of battery installed comes from Bateman's itself.

Within the loft above an outbuilding where Kipling's old Rolls Royce is displayed, is a large, dusty wooden box. The box is labelled "Harrods Ltd Knightsbridge" and is itself clearly many years old. However, within the box are hundreds of long thin glass tubes. These are rumoured to have been at Bateman's for many years and are clear evidence that a large number of batteries were installed.

[i] The regulator could have been adjusted to compensate, but this would have been very inconvenient as it was 250 yards away!

Figure 20 - Glass tube

The tubes are all identical, being 12 in. long and ½ in. wide. They are made of clear glass, having a slight bell at one end much like a test tube. The other end is rounded with a small aperture, thus making the tube open at both ends.

At first sight the tubes are an enigma - they obviously served a purpose, but what use is a tube that is open at both ends?
The answer to this question is found by reference again to old electrical installation books[14,15&16&17] and obtaining help from the National Museum of Science & Industry[i].

Investigation reveals that the tubes were used as "plate separators" in a form of storage battery known as a "secondary cell".

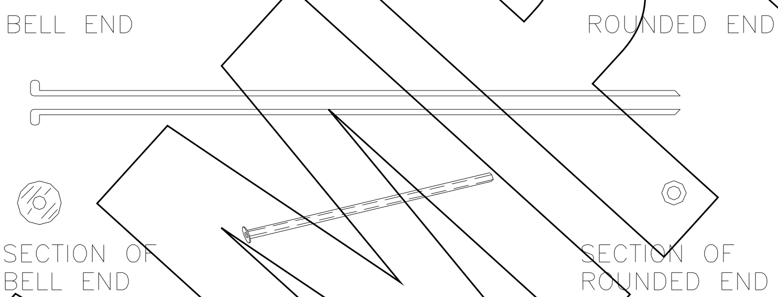


Figure 21 - Diagram of glass tube plate separators

The battery would have comprised of a number of rectangular plates, immersed in a weak acid solution. The principle of operation of the cell was based around early experiments and developments made by various parties[ii] between the years 1850-1900 using "lead acid" technology. The principles of the battery having been discovered and initially developed by such pioneers are Plante[iii]
Messrs Gladstone & Tribe found that using certain combinations of lead, metal and lead oxides as positive and negative plates within a weak sulphuric acid solution, a stable, reliable and long lived battery could be made.

A typical plate for such a battery is shown in figure 22. The plate had a lattice structure which was filled with a lead oxide paste compound. The plate had lugs which protruded out of the solution and were connected to similar plates in a set of

[i] Who hold a great many old books !
[ii] Gladstone & Tribe
[iii] Responsible for development of the Plante cell.

"elements". The negative and positive plate had to be separated from each other in order for the battery to operate and it is here that the glass tubes were used.

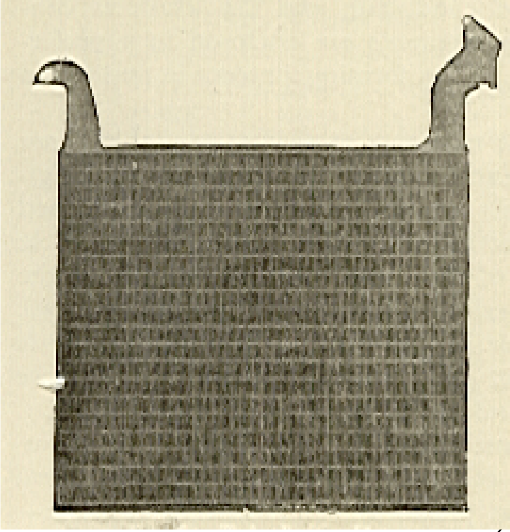


Figure 22 - Typical lead plate[18]

Mounted vertically and suspended on a suitable wooden bracket, the tubes ensured a gap of about ½ in. between the plates. The glass did not react with the acid, neither did it float, because it was hollow. Two or more tubes would have been installed between each plate pair. The arrangement similar to that shown in figure 23.

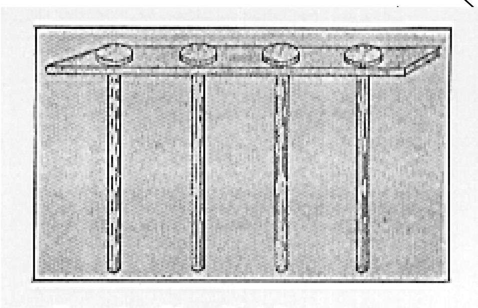


Figure 23 - Glass tubes on suspension[19]

The whole set of elements and the acid solution would have been contained in a glass container - again to avoid corrosion. The whole container would have been fitted with wooden feet or edge protection and been roughly cube shaped having dimensions approximately 10 in. wide x 8 in.deep x 12 in high.

There were several configurations of the above type of battery used at around the turn of the century. It is, however, likely that the cells were of a "Tudor" pattern, illustrated in figure 24.

The tudor cell was commonly used for lighting installations. The cell had a stabilised output of 2volts and was, as can be seen quite simple in it's structure. Obtained from a book dated 1909, the illustration clearly shows the glass tubes in situ.

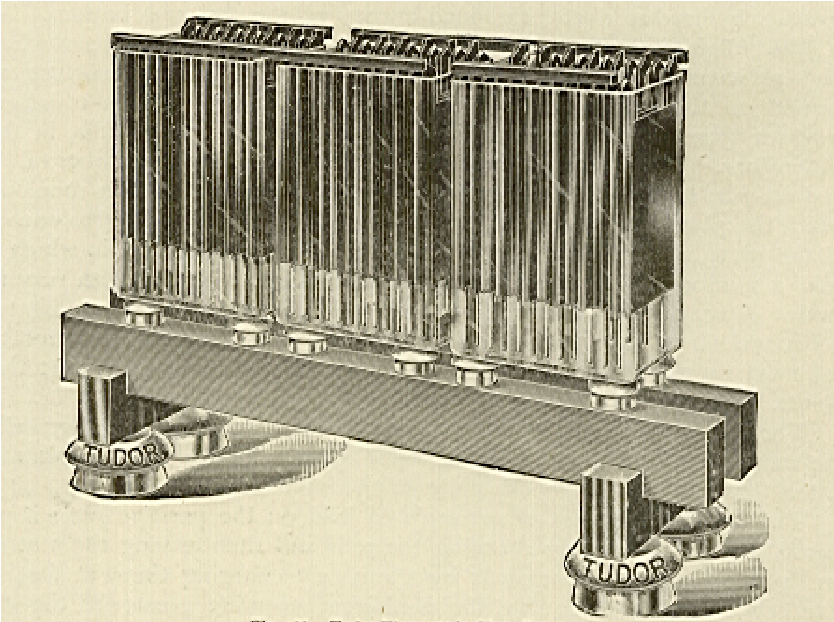


Figure 24 - The tudor cell[20].

Taking a moment to consider the cell and it's application at Bateman's, the supply voltage of 100v DC would have required 50no cells, each providing 2volts and connected in series. The illustration above shows 26no glass tubes per cell, meaning that 1300 tubes would have been originally present. The tubes in the loft haven't been counted, but their number is certainly in this region.

From the above, we can now surmise that the 50no cells, would have been connected together in a single bank, and allowing for a certain amount of access over the top and around the sides of each cell, could have been stacked on suitable wooden shelving in group of five across five high and two deep. This would have taken a space of approx. 5ft wide by 6 ft high by 24in. deep, the assumed battery room would easily have accommodated this arrangement, without being oversized for the purpose.

This type of battery would have required a stable charging voltage of slightly more than 100v. As was seen earlier, a voltage regulation mechanism is present on the switchpanel within the dynamo house. Hence it is likely that when the turbine was set in motion, probably once a day, the voltage would have been adjusted to the correct charging voltage. It is possible that a second voltmeter would have been installed within the battery room, to save walking down to the dynamo house to check. Adjacent to the "DIY" equipment within the dynamo house is a second old voltmeter, it could have originally been installed in the battery room although there is no way to verify this.

In fact, this simplified form of regulation was far from optimal. Old installation guides indicate[21] that the charging circuit was normally more complex than this. It is possible that additional regulating equipment such as dummy loads and switches were installed. The writer has suspicions, albeit unproven that the porcelain resistors screwed to the wall next to the "DIY" wiring in the dynamo room, are in fact part of an older regulating system.

4.10 *Internal House installation.*

From the batteries, a supply cable would have been passed into the house. As has been discussed, this cable is thought to have entered the house within the basement. There is still an old lead sheathed armoured cable in evidence, albeit cut off within 12in. of the entry hole.

Figure 25 - Old cable entering building

The type of installation installed within Bateman's would probably have been similar to that within any other house at the time. It is not possible to say exactly what type old cabling would have been used, but contemporary wiring systems relied upon stranded copper conductors with a rubber insulation around the central conductor.

Sometimes the cable was sheathed (often with lead) but it is very likely that the installation at Bateman's comprised of unsheathed separate single cables, run through floor voids and hollow panels. Where it was not possible to conceal the cable, then it is probable that a wooden moulding may have been used to improve aesthetics and protect the cable.

This system was used for many years and became known as "Capping & Casing".

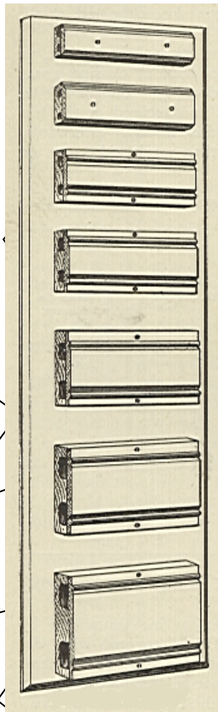


Figure 26 - Capping & Casing[22]

It is just possible that the cabling could have taken the form of a flexible conduit system. It would have been a very new form of wiring at the time, but such systems became common in about 1908[i] due to the ability to run long lengths of flexible pre-armoured cable throughout the building. It leant itself to "fishing" through cavities and was ideal for an existing building such as Bateman's.

The conductors were still copper and insulated by rubber, they were, however enclosed in a steel tube composed of convex & concave strips, wound spirally around each other so as to interlock.

One piece of evidence that leads one to suspect that flexible conduit was used, is the cabling between the switchpanel in the dynamo house and the "DIY" board above where the underground cable leaves the dynamo house. This interlinking piece of cabling is in fact a piece of this early flexible wiring - very rusty but still intact.

[i] Many different types of installation were being experimented with at the time. Many fell by the wayside, like this one.

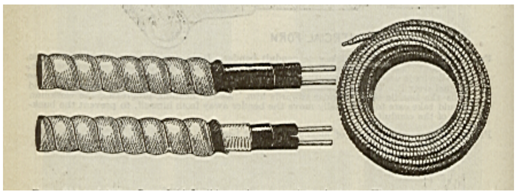
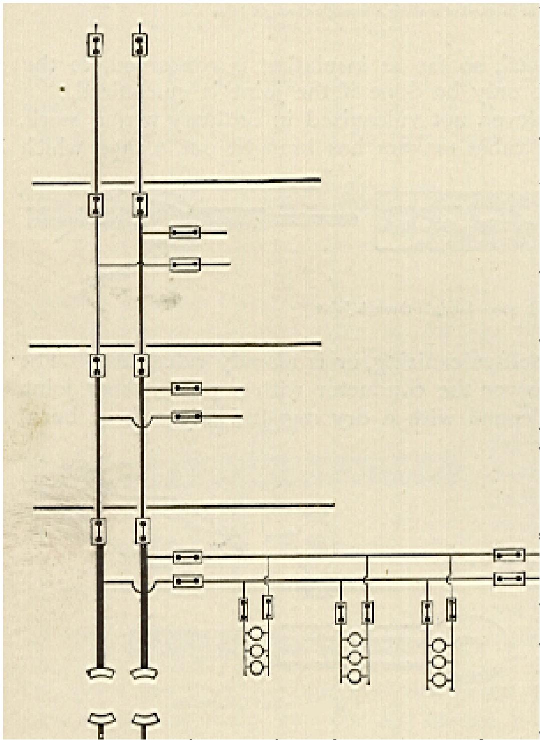


Figure 27 - Flexible armoured wiring[23]

It is the writer's suspicion that this and other items (including the switch) may have been reclaimed from the house when the DIY wiring was first installed.

Methods of internal building wiring were in the early days of development. The principles of overload & short-circuit protection, although appreciated, were commonly not implemented.



A distribution system similar to that shown in Figure 28 would probably have been installed.

Main "feeders" would have been run around the house, with "sub-feeders", "branches" and "taps"[i] being extended to more remote areas of the building.

Small fuseboxes may have been installed where the size of cable used was reduced. Called "cutouts" these would have contained bare-wire fuses

A main bank of "switches & fuses" may have been located at the point of supply most likely in the basement. This system came into common practice[ii] in ~1905 and so may have been used here. In this case the arrangement would have been more similar to that in Figure 29. It would have been unusual for

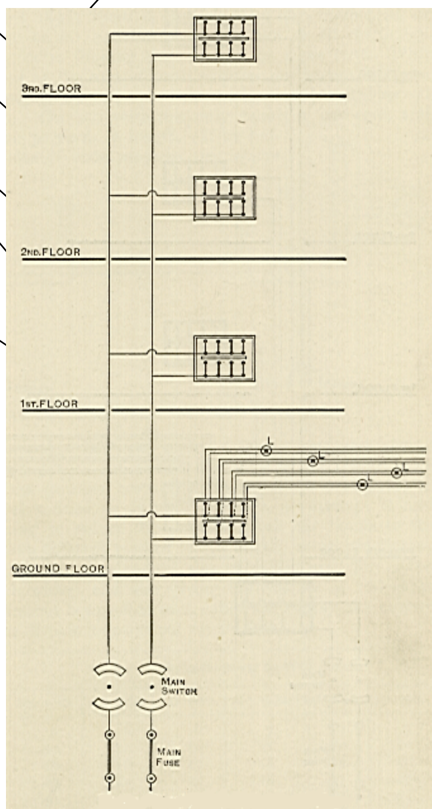


Figure 29 - Distribution board system of wiring[25]

[i] Common names for various spur connections.
[ii] This more advanced system was the predecessor of modern sub-distribution systems.

relatively small installations to have complex wiring systems.

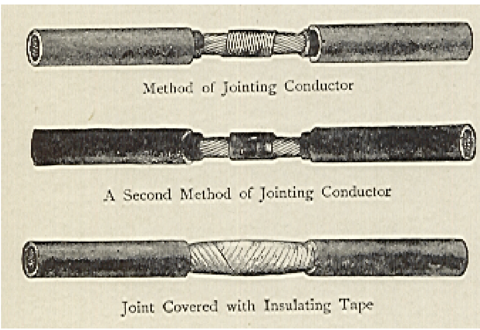


Figure 30 - Jointing of cables[26]

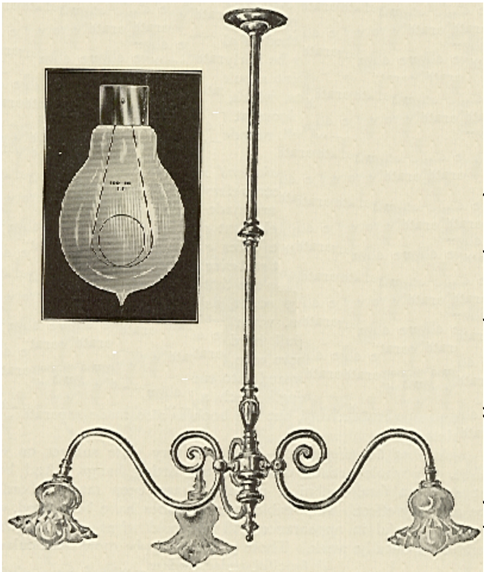


Figure 31 - Period lighting fitting[27] *with 16 candle 100V lamp*

Figure 32 - Period lighting switches[i]

Intermediate joints would have been made using the recommended method at the time, twisting the cores together in a certain fashion and taping the joint with a form of suitable insulation tape.

Lighting fittings were normally in a style that was similar to the gas lamps that were common at the time in houses where electricity was not installed. Indeed, many of the contemporary manufacturers also manufactured gas lamps.

Figure 31 shows a typical lighting fitting of the time. Note the old fashion swan neck-this was very similar in design to contemporary gas lanterns. The lamps that were fitted would have probably been swan lamps, a standard product at the time. Each would have been rated at 16 candle power - approx.63W.

Lighting switches were ornate items, commonly brass but often painted porcelain. As has been mentioned, it is possible that brass switches were used due to the fact that there is still such a switch installed in the dynamo house.

Some illustrations of contemporary switches are shown in Figure 32. It is speculation as to which type may have been installed.

What ever the exact nature and type of installation, it is certain that the wiring and equipment would have been removed as soon as a public supply was made available at Bateman's, because the public supply voltage would have been both higher and of course, it would have been an Alternating Current (AC) supply.

[i] These photos are from the writers own collection of period lighting switches. Not all are as old as the Bateman's installation.

4.11 *Kipling's account.*

Broad statements have been made above about the involvement of Kipling himself in the installation of the dynamo and associated equipment.
The fact that he was personally involved is well documented, although not in conventional engineering literature.

Towards the end of his life Kipling like many other writers, prepared and wrote an autobiography. Entitled "*Something of Myself*"[28] the work is unusual in its depth and detailed descriptions of the events and situations that affected his life.
The installation of the turbine, dynamo and cable, are all described sometimes humorously within the book, being found in Chapter 7.

It is evident that Kipling was not satisfied with the house only being lit by means of lamp or candlelight. Kipling describes the way in which a chance meeting with a Victorian engineer, Sir William Willcocks, resulted in the mill-pond being cleared of debris, having trees removed around the edge and having the sides banked.

Evidently Sir David gave much more advice including the horse power (4.5hp) that could be expected from the turbine. This knowledge, we are told by Kipling, was due to the fact that Sir David had designed the Assouan Dam across the River Nile in Africa.

Kipling describes how it was Sir David that said "*Don't run your light-cable on poles. Bury it*" Presumably Kipling had been considering an overhead installation.

Kipling notes,
"We got a deep-sea cable which had failed under test at twelve hundred volts - our voltage being one hundred and ten - and laid him in a trench from the mill to the house, a full furlong, where he worked for quarter of a century. At the end of that time he was a little fatigued, and the turbine had worn as much as one-sixteenth of an inch on her bearings. So we gave them both honourable demission - and never again got anything so faithful".

The text goes on to describe his friendship with his general contractor and the fact that in later years it was a London contractor who installed the eduction pipe.

Kipling obviously used local labour where possible. A description of the labourers reactions when they excavated some timberwork during installation of the turbine, which promptly turned to dust in front of their eyes, indicates that he enjoyed working alongside the "common man". It is entertaining to consider what he would make of modern day electricians and installation engineers !

Kipling even wrote a poem called "The Dynamo" it is reproduced and duly acknowledged with thanks at the front of this text.

It is rare to find such enthusiastic accounts of the installation of electrical installations and shows that the writer must have had a "down to earth" nature.

4.12 *Christy Bros & Middleton.*

It is not every contractor who could, at the beginning of this century take on the job of the complete installation such as that installed at Bateman's. Nevertheless, the chances of the original company who did install the system still being in business are surely remote. In fact the firm *is* still in existence (just!) after what amounts to nearly 130 years in the electrical business.
The story of Christy Electrical Ltd as they are now known, is one of great interest. It is discussed in brief here in order to gain an idea of how the electrical installation may have been commissioned and installed at the time of the installation.

In 1858 a Mr Fell Christy of Chelmsford started business as a millwright and engineer. In these time of expanding industrial premises, the business did well. It is pure speculation that possibly during this time, the company may have had some involvement with the old flour mill at Bateman's. The company specialised in flourmill machinery and equipment.

Twenty Five years later in 1883, Fell's son Frank Christy (1865-1957) started up an electrical business in Broomfield Road, Chelmsford.

Frank had served an apprenticeship with Colonel R.E.B Crompton who had established the well known electrical company Crompton & Co, Chelmsford in 1878. It can be noted that it was a Crompton & Co dynamo that was used at Bateman's presumably picked up from just round the corner!

At this time their work extended from the installation of generation equipment (all private in those days), right down to the installation of lights in buildings - the whole of the electricity supply, distribution and use business.

The company specialised in the conversion of water driven flourmills for electric driving - showing their links with their sister engineering company. Mills were usually running day and night and were hence amongst the first premises to receive electric lighting & power.

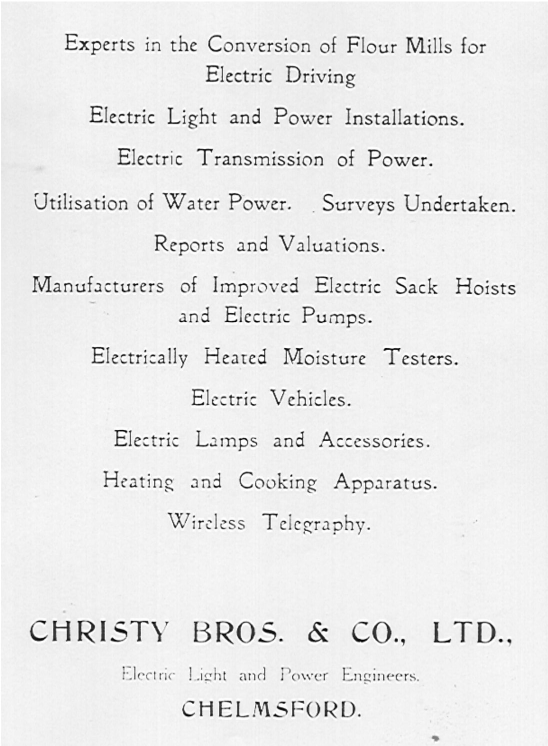


Figure 33 - Christy Bros & Co[29].

The company quickly took advantage of the growing market, and in 1898 were joined by a Mr William Middleton. He became a partner and the firm became known as Christy Bros & Middleton.

We know that in 1906, Mr Middleton left the company and the firm subsequently became limited. Hence we have a timeframe of 8 years during which the installation at Bateman's could have been installed - the brass plate on the switchpanel bears the name Christy Bros ***& Middleton.***

Around the time of the Bateman's installation, the company were also specialising in the installation of small hydroelectric power generating schemes, generators linked to oil driven internal combustion engines and domestic lighting installations. The business had now expanded to cover many parts of the country. In addition to Bateman's some prestigious premises were worked in; Terling place - home of Lord Rayleigh, Chelmsford Hospital and Royal Eastern Counties Hospital to name a few.

It should be remembered that in these days, the installation consisted of the initial installation of lighting - not rewires. Hence the contracts all involved the careful installation of wiring and equipment onto existing decorations and building structures that were not designed with electric lighting and wiring in mind.

Christy Bros Ltd went on expanding and between the years 1920 and 47 became heavily involved in the design and installation of electricity distribution and supply to towns and villages throughout the country. Many towns in East Anglia and the west of England were served by a supply system installed, operated and maintained (still privately) by Christy Bros & Co.

It was in 1948 that the various large private supply systems such as those installed by Christy Bros & Co throughout the country, were nationalised by the British Government. Christy Bros & Co subsequently merged with their sister company Christy & Norris to maintain financial strength. The company still maintained a name in the milling engineering business but the electrical division now concentrated on Contracting work.

Numerous acquisitions, mergers and take-overs ensued during the second half of this century.
Frank Christy died in 1957. It is recorded[30] that he left money to every employee in the company as part of his will. He and Christy family were in fact Quakers and he had always ran the company with a Christian and fair approach.
The company eventually grew to the point where it was a major employer in Chelmsford. In 1973 it had an annual turnover of more than £12million p.a. However, due in part to economic climate (also to mis-management, Frank Christy having died) the end result of all of these changes was the fragmentation of the company during the 70's and the eventual disbandment of all but some very small parts of the company.

These days, all that remains of the electrical business that started nearly 130years ago is a small quality panel building plant in the outskirts of Chelmsford. The company is however, well aware of it's history and some records still survive (although many were destroyed in the 70's)

One interesting source of reference is an extract from an advertising leaflet dating from 1923[31]. This contains a list of some of the installations carried out during the life of Frank Christy (who apparently liked to become personally involved in the company projects). The list details many types of premises, some large, some small. However, listed under "Country houses and mansions" is a reference to Rudyard Kipling Esq. Batemans, Burwash.

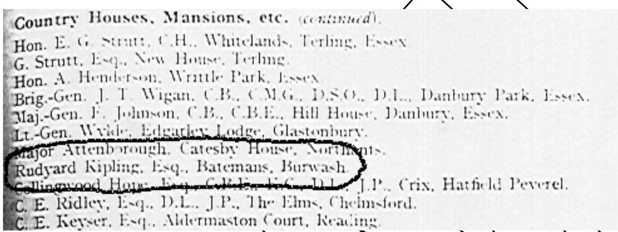

Country Houses, Mansions, etc. (continued).
Hon. E. G. Strutt, C.H., Whitelands, Terling, Essex
G. Strutt, Esq., New House, Terling.
Hon. A. Henderson, Writtle Park, Essex.
Brig.-Gen. J. T. Wigan, C.B., C.M.G., D.S.O., D.L., Danbury Park, Essex.
Maj.-Gen. F. Johnson, C.B., C.B.E., Hill House, Danbury, Essex.
Lt.-Gen. Wykle, Edgarley Lodge, Glastonbury.
Major Attenborough, Catesby House, Northants.
Rudyard Kipling, Esq., Batemans, Burwash.
Collingwood Hope, Esq., [illegible] J.P., Crix, Hatfield Peverel.
C. E. Ridley, Esq., D.L., J.P., The Elms, Chelmsford.
C. E. Keyser, Esq., Aldermaston Court, Reading.

Figure 34 - Christy's past projects (1923)

Not much else is recorded about the installation at Bateman's. However, some references exist to a subsequent installation at Wimpole Hall, Hertfordshire for Kipling's Daughter, Mrs Bambridge. This leads one to suspect that Kipling maintained contact and possibly even used Christy Bros & Co on more than one occasion.

The History of Christy Bros & Co is described more fully in Bill Tincknell's book "The Christy Story".

4.13 *Current Situation*

The installation is obviously out of commission and is in no state to be used.
The turbine itself was overhauled in 1985 by the Royal Engineers as an apprentice training exercise. Until relatively recently, the turbine was run up on occasion.
However, the equipment is in general too old be safely brought back into operation. The switchpanel would not comply with any of the modern day safety regulations, and even if the house end of the cable were to be found, it is bound to have developed serious earth faults.
It is therefore sadly the case that at best, the equipment could be retained to look at, but not to use.

A point of concern as with any metallic and electrical equipment, is that the damp surroundings and low winter temperatures will eventually lead to the deterioration of the equipment and the ruination of this interesting historical installation.
It is therefore hoped that the equipment will in due course receive the environmental protection it deserves.

That an installation such as that installed at Bateman's is still in existence is remarkable. However, when it is set against the problems that beset engineers in the earliest days of electrical engineering such as poor performance, poor efficiency and limited equipment, it is remarkable to consider that it worked at all; let alone for 25 years.

The system is a tribute to earlier engineers and we must not forget that "pure engineering" is often a good substitute for high technology.

5. Private Power Generation - Modern solutions to old problems?

Common modern methods of private generation were discussed in section 3 of this text and it was seen that schemes such as the system installed at Bateman's are not these days used. Why not?

Well the first and most obvious is that there is very often little need to explore alternative forms of energy because modern fuel is so cheap. Gas in particular is cheap and can be easily obtained either piped or in stored liquid form. Hence for standby or backup means there is no need to consider cheaper forms of energy. Despite much rhetoric from the industry, environmentally friendly but non-cost effective private schemes will never be installed.

A hydroelectric scheme such as that described above would these days be expensive to install. Equipment would have to be specially manufactured, and the battery systems inparticular would prove very expensive due to the cost of modern storage cells and charging equipment.

However, as a means of mains power generation for remote sites where fossil fuels are unavailable, such systems may be initially attractive.

The second main reason is the loading requirements of modern installations. Whilst undeniably more efficient, modern day electrical equipment is so widely used that even a residential house has a substantial load requirement.

Kipling's generator and battery system, supplying approx. 15Amps would quickly have been overloaded in any modern house.

Even if modern machinery were used and rotating turbine operated at 100% efficiency driving a generator and cable network also at 100% efficiency, the systems would still be limited to the available power delivered by the mill-pond …7.5hp ! (~5.5KW)

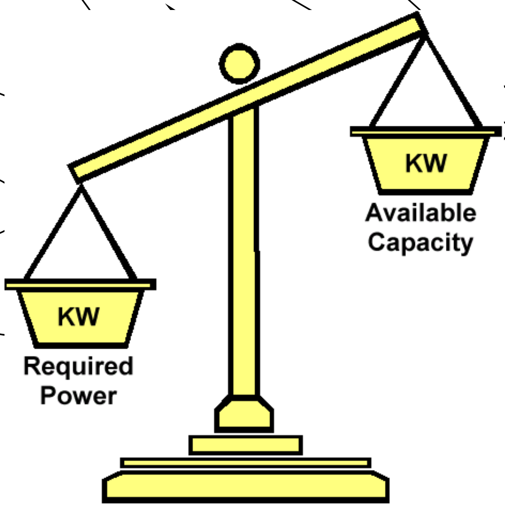


Figure 35 - The scales don't balance !

Modern charging circuits combined with state of the art cells can store large amounts of energy with just a "trickle charge" However, the cells would eventually run down on all but the lightest load. Eventually the dynamo would be required to serve the load directly, which it clearly could not do.

We can see then, that although the energy is available for free, there is not enough of it to enable realistic modern use. This does not necessarily preclude the use of such hydroelectric power schemes in situations where more energy is available, but such sites are unlikely to be available to the private individual[i].

This coupled with the capital cost of such an installation, leaves us sadly to conclude that such an initially attractive small generation system would not meet the need of a modern day installation.

Notwithstanding the above, the principles adopted by Kipling and his associates, need not necessarily be discarded. The idea of a reliable battery storage installation, is not out of date, indeed, it is much used where the reliability of a supply is needed.

The Uninterupptable Power Supply (UPS) common in installations where data equipment and computers are served, relies on rechargeable secondary (storage) batteries. Being modern day descendants of the cells used at Bateman's these cells are long lived and as long as they are sufficiently charged, can serve sizeable loads for long periods.

So what prime mover could be used to charge such batteries and hence run a typical complete modern installation for 24 hours a day? Well clearly a large water turbine would be nice, but these as discussed, are not practically possible. Neither are fuel fired generators, as it would prove false economy; the installation could just as well be served from the generator directly.

What is needed is a cheap form of energy that is abundant although not necessarily constant. Such a form of energy is daylight.

Until recently, few alternative sources could have been economically harnessed to produce enough power to charge such battery systems. This included sunlight, because although it is abundant in quantity, we have always lacked a means to efficiently collect sunlight and convert solar energy to electricity.

However, in recent years, ongoing development of Photovoltaic[ii] technology has produced a means to do just this.

[i] Not many people have amounts of running water on their land far exceeding that at Bateman's.
[ii] A process by which electrochemical action, enabled through solar energy, creates a small electrical current.

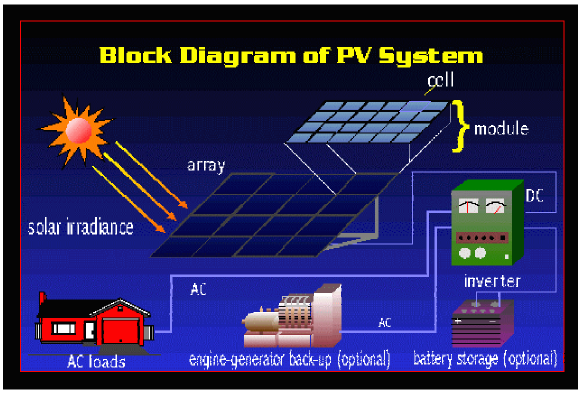


Figure 36 - Photovoltaic action

A photovoltaic cell comprises mixtures of advanced compounds (Cadmium, Selenium, Aluminium, Arsenic, Indium amongst others), that when exposed to sunlight, produce an electrical current. Formerly very inefficient at converting such energy, these cells are nowadays able to produce up to an output amounting to 100W per square metre[32]. Such maximum output is rare, but when combined with many other cells, the total array is able to produce sizeable quantities of electricity, even in Britain during the winter.

The falling prices of such cells has all of a sudden meant that it is possible to economically install many arrays of such cells, and to use the electrical current produced during the day to charge storage battery systems.
Many initial environmental problems & concerns relating to the production of such cells have now been overcome, to the point where such systems can be easily termed as environmentally friendly.

It is now possible to install photovoltaic cells so that they form an integral part of a new building's roof structure. This produces a very large useable area (hence a high electrical output). Which is in exactly the right place to gather maximum sunlight.

We are still far from the ability to serve the whole installation in a building 24 hours a day from such sources, but it is clearly a very attractive means of private power generation.

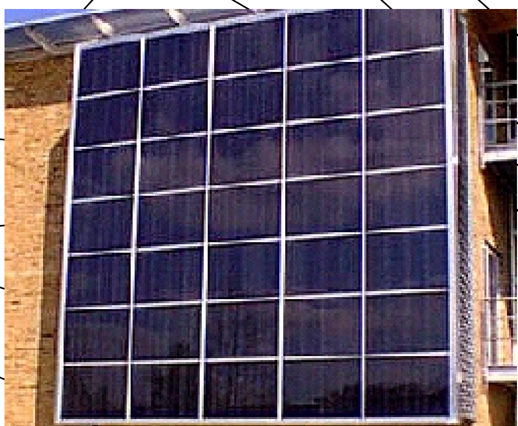


Figure 37 - The "Photovoltaic building"

Several modern buildings have now been built using such technology to supplement public supplies (to minimise energy costs), and it seems likely that in the future, even domestic premises may be able to be fitted with such systems.

At this point the cycle may have turned full circle. The rich domestic user, may one day be able to install a battery room, charging equipment and a set of photovoltaic cells on the roof, and serve the electrical installation within his house from such an arrangement, without having to rely on public supplies.

This is clearly a slightly utopian view, but it does illustrate a point - that the basic problems relating to electrical energy supply are not new - that modern solutions may be used to overcome these problems - but that the principles are never far from those used by engineers of the past.

6. Conclusions

The preceding subjects, have obviously been dealt with fairly briefly and are extensive subjects on their own.

In particular, background to the turbine and dynamo at Bateman's and the early electrical installation within the house could be further researched and expanded on. We have, nevertheless been able to draw the conclusions that such systems are not practically or economically viable in today's, energy hungry world. They have been overtaken by our greed and reliance upon electrical goods and equipment.

Small, user friendly and environmentally friendly hydroelectric systems, once common in large country houses will sadly have to remain in the history books, or rarely, such as the system at Bateman's, in the ongoing care of guardians like the National Trust.

We can pay tribute however, to the ingenious methods and marvellous craftsmanship of our predecessors.

It is possible to conclude, that there is much to be admired and considered in the way that a building could be self-sufficient in electrical energy - particularly if such supplies are reliable and environmentally friendly. The small scale implementation of new technologies such as modern photovoltaics, enables us to realistically consider substantial reductions in fossil fuel use and energy costs.

It is therefore with great interest and a deal of excitement that we look forward to the future and wonder what systems will be installed in 100 years time. What technology will they use? and importantly, will any of the techniques and ideas used be similar to those implemented by early users like Kipling and his contractor Christy Bros & Co.

The writer suspects that in 100 years time the systems, although high tech, may still, like those used 100 years ago be surprisingly familiar.

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