NEWSLETTER December 2017

i) COMMENTS

A Merry Christmas to everyone. PEEMS has had a very varied year in 2017 with quite a few successes and a few disappointments. Many new people have been turning up at our club meetings, expressing the desire to became members, and the attendance at meetings has also been good, so much so that our subscriptions this year have not had to increase. In fact, at our AGM in November our treasurer assured us that our finances are still healthy and 'in the black'!

The year started with Mike Sayers very generously giving PEEMS permission to use the full workshop area, on his site, and during the year the workshop has become fully functioning. This began in February with the delivery of the milling machine from George's workshop to our own. Much work has been done by members insulating the workshop, and installing the electrics, with the effect that all equipment had been installed, and made safe by August, not bad going!

In February we were given an excellent talk by Roger Taylor on car engine management and fuel injection systems, where the essential components were explained in detail. In March the club members were treated to a very nice (*I'm trying not to use the word 'excellent' all the time. Ed*) annual dinner at 'Oscars' in Norton, organised by our previous Chairman Jim Everett.

We have had two 'Bring and Brag' meetings during the year, with the March club meeting resulting in nine exhibits, and the October club meeting resulting in thirteen exhibits, a healthy increase, and illustrating the very high standard and variety of member's abilities and skills. The March exhibits included 1/3rd scale Bentley magneto parts, a precision light pillar drill, a planetarium, a high-speed milling head, a multi-angle vice, an inverted vee twin steam engine, a 'soda can' Stirling engine, 16mm narrow gauge locomotive tender, and a ¼ scale model jet engine.

April saw PEEMS once again having an excellent talk by Martin Sanderson on Walnut Woodwind and Brass Instrument Repairs. In April, the first visit of the year was to the Newark Air Museum. This was so good that it is recommended that PEEMS should consider this again (*but maybe that's because I'm an 'air -head'! Ed.*).

May brought one of the big events in the PEEMS calendar with the Doncaster Show. There were 13 members exhibiting 46 items ranging in size from Chris Bramley's 'Thrashing' Machine to Richard Gretton's small drill sharpening jig. The quality of the exhibits was very high indeed. Richard was commended for his excellent organisation of this event.

Another big event occurred in June and this was Mike and Pat Sayers' 'Final' Garden Party. This was held to support two important local community projects 'First Steps' and 'Ryedale Special Families'. In addition to wonderful catering by Pat's team, there were many model exhibits and classic cars, and substantial donations were raised for the two community projects. Ted Fletcher also gave a very informative talk on "Electrical Hints and Tips for the Home Workshop". This was a talk by an expert and gave some very useful inexpensive and practical methods to make your workshop electrically safe.

In July we had the 'Mike Sayers' Trophy' night where there were five entries including a half beam engine, an Appalachian dulcimer, a ¼ scale jet engine, a model loco turning display stand, and an electric powered model 08 diesel shunting loco. The Trophy was won by Brian Stephenson's half beam engine. Brian said that it was disappointing that only five exhibits were on display this year. He hoped that there will be more members displaying their projects next year. July also saw a PEEMS family visit to Scarborough's North Bay 20" gauge Railway (NBR). At least thirty-two members and guests enjoyed the 7⁄8th mile (1.4 km) journey between Peasholm Park and Scalby Mills, pulled by the steam engine 'Georgina'. NBR were also very hospitable in allowing 'steam-head' PEEMS members to ride on the footplate in both directions. The evening was completed with a visit to the engine sheds to view the other locomotives.

In August it was announced that the workshop was fully functioning and being monitored by an appointed safety officer Eric Foot. The Club Meeting in August was a 'Bring and Buy' auction where our chairman Jim Everett gave a good impression of an auctioneer. Many items went under the hammer, with the auction taking place over an hour.

In September PEEMS members were treated to a very informative talk on 'The History of Photography' by Bruce Pickering. The talk was illustrated with historic cameras, lenses, shutters and film carriers, and culminated with a demonstration of carbon printing. During the month, PEEMS members exhibited models in the 'Learning Centre'

on Platform 2 at the North Yorkshire Moors Railway. Once again, the quality and variety of the models was very high, but there were issues with the location, which was on the opposite platform to the passengers This resulted in footfall not being as much as expected. Whilst the previous exhibition on 'Gala Day' was regarded as a success, the Club made very little profit on this outing. As with the PEEMS railway, (see below), the Club will have to decide how mounting an exhibition at the station should be approached in the future, with regard to signage, location etc.

In October there was another 'Bring and Brag' which included scale model Bentley engine gearbox parts, a spring chuck, a double roller filing rest for lathe work, an apparatus for laser scanning objects in order to 3D print copies, manufactured gearing to speed up a milling machine for model engineering, a gearless clock, a clock repair, a quarryman's coach and slate trolley for a 16mm garden railway, a steam engine for a 'Windermere Launch', a tool holder for a lathe, manufactured tooling for a lathe, a 'Hobson' injection carburettor, and a Midland Railway 4-4-0 'Deeley' 4P locomotive build.

The two main events in November were the Annual General Meeting and the visit to the workshops at the National Railway Museum (NRM) in York.

At the AGM, Jim handed over the Chairmanship to David Proctor for the following year, and vice chairmen were elected to succeed in the following years. PEEMS thanks Jim for his expertise in chairing the club for the last year, and for the implementation of his slogan *'Adapt, Adopt, Improve',* whereby his aim had been to reduce the workload on officers and spread the load over a greater number of members, both on and off the committee. His aim had been to bring new blood into the committee.

Summing up, he said that everyone has a part to play and many PEEMS members had been very active during the past year. He thanked everyone for their efforts, making his job both easy and enjoyable. Other officers were elected for the following year.

Simon Holroyd, the NRM workshop manager gave PEEMS members a tour of the facilities which are not normally open to the public. It was very interesting because the members were able to see the dismantled 'Sir Nigel Gresley', undergoing restoration, and the dismantled 1979 replica Stephenson's 'Rocket', with its restored boiler available for examination. The tour included the machine shop areas, and the various slotters, shapers, lathes, milling machines and grinders used in the shop. All the machines had been donated to the museum, but there was no CNC!

Peter Bramley has now retired from the PEEMS Railway and committee (he wants to spend more time in his workshop!). PEEMS thanks him for his commendable service over the years. PEEMS has decided that the railway will run for another year before a review is taken on its continuance. Whilst the opinion was that this year the railway attended too many events (seven in total), with some disappointments, three events were excellent. These included Welburn Hall School, a community outreach, in June, and the Ryedale and Malton shows in July which were excellent. Malton show was good because the Young Farmers provided the "heavy lift". PEEMS has decided that for 2018 we should concentrate only on those three events. It is acknowledged that the current members engaged with the railway are getting older, and the assembly and dismantling of the railway requires some heavy lift preferably with younger people. Incidentally, we did make revenue by providing the PEEMS locomotive to the Cedar Barn restaurant when theirs broke down!

2017 saw the introduction of the 'Clock Focus Group' set up by John Powell for those interested in all aspects of clock construction, repair, tool making and joint projects in the workshop.

Let us hope that in 2018 things will be even better (where have I heard that before?), oh and I forgot……..
…….HAPPY NEW YEAR!

As you can see from your calendars, there will be no meetings in January, except for the workshop morning on Tuesday 16th January. Club meetings start in earnest on the 7th February. <u>There will be no newsletter in January.</u>

ii) FORTHCOMING EVENTS

- **Workshop Morning:** Tuesday 16th January: 10am to 12 noon.
- **Club Meeting:** Wednesday 7th February ~ Design and Manufacture of Composite Structures – Nevile Foster
- **Workshop Morning:** Tuesday 20th February: 10am to 12 noon.

Club Meeting 6th December With A Talk By Richard Gretton On Clock Making.

Chairman's Comments.

There was a very good turnout for the club meeting, with two new guests, Stuart and Jonathan.

Prior to Richard's talk, our new Chairman David Proctor informed us that he had investigated, and found that there was no need to change our 'Articles Of Association' in order to increase the number of officers in the club.

- The annual dinner, planned to take place on Friday March 16th 2018 was then discussed. The choice of venue for the 2018 annual dinner was raised. The Chairman outlined several options and solicited feedback from the members. Based on the feedback at the meeting, the tentatively preferred option was the Forest and Vale (with the alternative venue of the Steam and Moorland restaurant), with no member speaking against this choice. A final decision is anticipated to be made by the committee before the next committee meeting, but other members preferences will be taken into consideration.

- There has been a request from Amotherby primary school, for PEEMS to be involved in their '2018 Science Week' which will take place in March. The school has advised that the theme of their 'Science Week' is 'Exploration', and would like PEEMS involvement specifically on Wednesday 14th March. A meeting with the school has been planned for early January, to discuss the support that PEEMS can give. PEEMS has been involved with Amotherby school before, for a similar event, and what was done then was very popular with the children.
  Tony Leeming suggested that those interested should form a sub-group. Ideally, about ten people would be needed.

- Mini 'Bring and Brags'. It is quite usual for members to bring their models to Club meetings, and it has been suggested that a good idea would be for the person bringing a model to explain the model and the challenges in the build. By this means new members and guests can see what is being produced by the membership.
  At this meeting, Mike Sayers started the Mini 'Bring and Brag, by bringing in his 'Wimshurst Machine' and his 1/3rd scale Bentley gearbox housing (see following).

- Workshop Masterclasses. Because of the vast knowledge and experience in the club, it has been suggested that the Workshop runs masterclasses in topics such as, for example, boiler making and wheel turning. David said that this was a topic he would really like to advance.

- Plans For Excursions. The wish list so far is:
  - The British Horological Institute Museum, Upton Hall, Newark.
  - The Imperial War Museum at Duxford.
  - The restored Holgate Windmill in York.
  - Manchester Museum of Science and Industry.
  - Scarborough Funicular Railway.
  - The Sour Gas Plant (Vale Of Pickering).
  - Raflatac, Eastfield Scarborough. Adhesives and Glue manufacturers.
  - The 'Flower Of May' caravan site in Scarborough has a museum with old motor bikes, cars, tractors, fairground rides.
  - Triumph Motor Cycle Factory, Leicester.
  - Coal Mining Museum Barnsley, River Don Engine, Sheffield, Anson Engine Museum, Poyton, Crich Tram Museum, Anderson Boat Lift and The Manchester Museum of Science and Industry. Note: this would be considered as a 'weekend away'.
  - Visit to Humber Bridge, Transport Museum, Art Gallery and Artic Adventure trawler.
  - North Yorkshire Moors Railway workshops at Grosmont.
  - Shipyard At Whitby.
  - Rolls Royce Lectures.

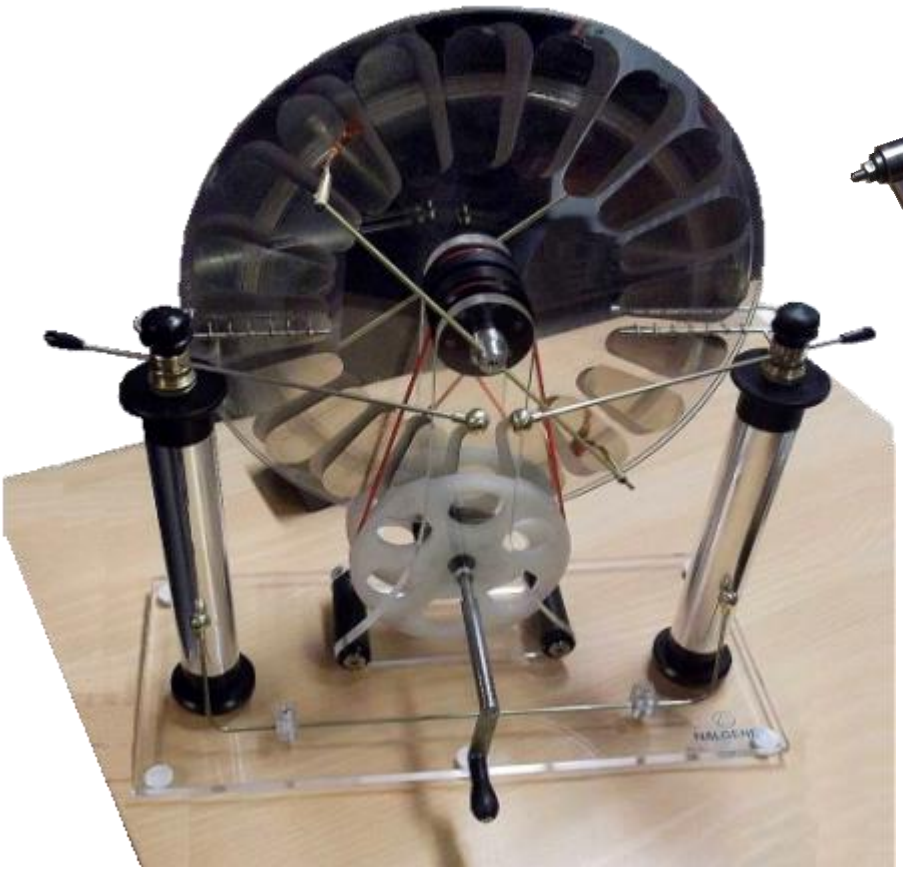
- Mike Sayers' Mini 'Bring And Brag'. As explained previously it has been suggested that we have mini 'Bring and Brags' at each club meeting.

  Mike started this club meeting by bringing two models :

  a) A Wimshurst Machine, an electrostatic generator invented fifty years before Van der Graff's generator. https://en.wikipedia.org/wiki/Wimshurst_machine
  b) The 1/3rd scale Bentley Gearbox which was in 'early cut' form at the previous 'Bring and Brag in October.

  Mike said that the Bentley gear box was still a 'work in progress', but he wanted to show how much progress had been made from the 'Bring and Brag' in October, when he exhibited the preliminary cut block and the blue 3D printed plastic template. It was currently close to completion, but he had experienced many trials and tribulations during the manufacturing process.

  The Wimshurst Machine was a Christmas present for his eldest grandson, and also a piece of fun for Mike himself. It had been completed since the previous workshop meeting, and was made from 'pieces of junk' found around the workshop. The discs are made from the tops of plastic display cabinets, the Leyden Jars are made from a 1.5" plastic waste pipe, and all the other bits were plastic and brass. The only parts bought were the ball races. All the clear Perspex is from a radiation shield from a laboratory. Mike had taken his grandson, when he was much younger, to the 'Frankenstein Workshop' near Grosmont, and he had found the whole experience absolutely magical. Mike had promised him he would build him a Wimshurst, but his grandson's mother said that if he did, his grandson wouldn't see his next birthday! He's now 14, so should now be responsible enough.



Richard Gretton's Talk On Clocks and Clockmaking.

Richard started by saying that he had been involved in the designing and the making of clocks, for about ten years, since he retired. Richard had always enjoyed making things, and has a workshop at home. Clocks had been an interest before he retired, but not a big interest, but they did become so, partly because he went on a visit to the BHI (British Horological Institute) at Upton Hall. When he got to the clock museum, he looked around the workshops, and thought "this is it !". What Richard likes about making clocks is, when you've made them, like with model engineering, you have something at the end that works. Unlike a lot of models, however, clocks work all the time, and in Richard's words are "Living Things".

Richard's workshop contains a lathe, milling machine and a pillar drill. A Taylor Hobson pantograph engraving machine is shown in the slide, for making clocks and their parts. The table at the back has a pattern on it, and the brass sheet is what is being worked on. This particular operation is called 'crossing out'.

This is Richard's lathe which is a Harrison 300. It is quite a sizeable machine, so it is not conducive for making small parts for clocks, but he has made use of it for just that. Here he is turning a blank for a gear wheel.

The other machine he has, is an Alexander Toolroom Milling Machine with its vertical head behind, and in front the dividing head attachment for it, with an arm and steady. Here he is cutting a gear wheel. As regards hand tools, he has all the usual model maker tools with good sets of drills and taps.

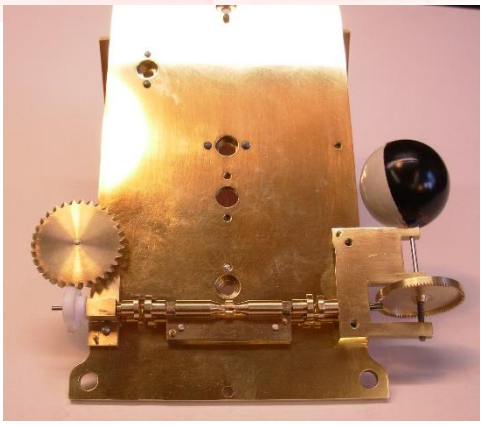
Please press on this link to see the video:
https://www.youtube.com/watch?v=cOwVBCvD7s0

Note: on all the videos, click the back arrow ← to return to the pdf.

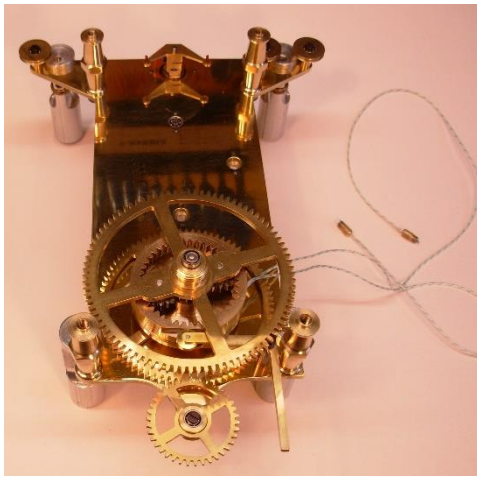
Brian Stephenson's 'Congrieve'. This what all model makers can make themselves. This is Brian Stephenson's 'Congrieve' clock, which Brian built from scratch.

The first thing to say about clocks and clock making, is that you do not need to design your own. You can buy a kit of parts. Richard saw a plastic clock with all the gears, dial and pointers advertised for £11.99p in a Christmas bulletin. The 'Congrieve' illustrates what a clock does. The ball rolls down the track. When the ball gets to the end it tips a lever. The mechanism at the top tilts the track the other way, and the ball rolls down again. It is really a gearbox movement. Every time the regulator, (which in this case is the table with the ball), stops, nothing happens. The gears aren't running, and suddenly the escapement goes, and the gears have to run again.

The Richard Gretton 3B Clock. This is one of Richard's designs. It was the second one he built. It is about 12" tall, and its pendulum runs with weights to drive it. There are two weights, one each side, running over the pulleys, as can be seen in the picture. It is a very simple clock with one gear train, and the escapement is 'pin and pallet'.
The concession to the design was that Richard does not like have to keep winding clocks, so all his designs have an electric rewind. When the weight on the right-hand side hits the little white button on the bottom (arrowed), it triggers the battery driven motor underneath which winds it up.
The clock isn't complicated, and the actual time keeping side is also not complicated, however, when Richard was designing it, he thought it would be nice to include a date wheel, and a moon globe indicator.

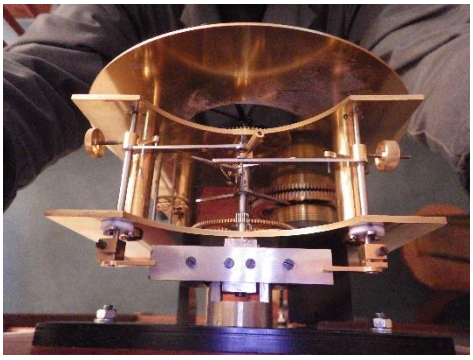


This is the clock taken apart, with a view on the back of the front face. The mechanism at the bottom is driven from the movement of the clock. On the left-hand side is the date wheel, with a right-angle drive. This is like a helical drive, but it only has two teeth on the nylon wheel. The shaft only rotates once every two days. On the other side is a set of gears, a little pinion, and a contrate wheel (bevel gear) driving a moon which is a ping pong ball painted black and white. This is geared to the moon's phase of about 28.5 days.

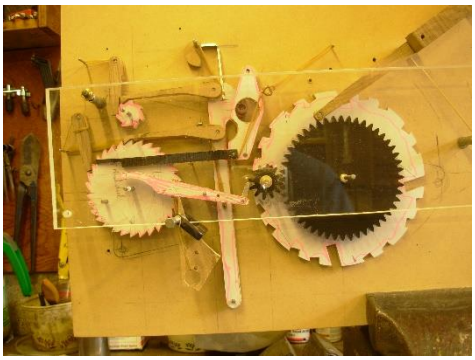


This is showing the Richard Gretton 3B clock with the gearing and the cords attached to the drum. The cords go over the pulleys and on the weights. The ends screw into the weights. The rewind drive and the microswitches can be seen. When grandfather clocks are wound up, the second hand stops and the clock stops, some will even go backwards. You want to be accurate, and sometimes it can take up to twenty seconds to wind a clock up, so in total half a minute can be lost. If a more accurate clock is required, then a 'maintaining power' is needed, which makes sure that while the clock is being wound, the clock keeps going. An epicyclic gear used for the 'maintaining power' is shown on the next page.

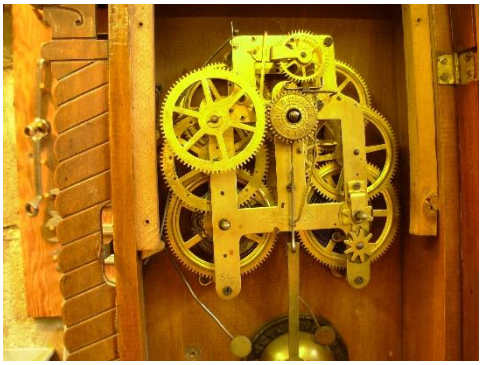
Under the base of the clock you can see the batteries, the motor, and the gear that drives the rewind mechanism, all hidden away. There are two micro switches to stop it over-winding. There is one at the bottom with the little white button, and then when the cone winds up on the drum of the clock, (the drum being the driving force for the clock), there is a little cam microswitch on that, so it only winds up to the same position every time. It has been very reliable.



This is another clock Richard has built. This is a one second pendulum wall clock. Richard wanted to show this, because looking down on the top of the clock, and at the back of the dial, you can see the escapement mechanism. It is what is called a “Double Three-Legged Gravity Escapement”, and it’s a take on Big Ben which has the same escapement. Big Ben is currently being taken apart to be serviced. Richard said that it was quite an achievement to build his clock.

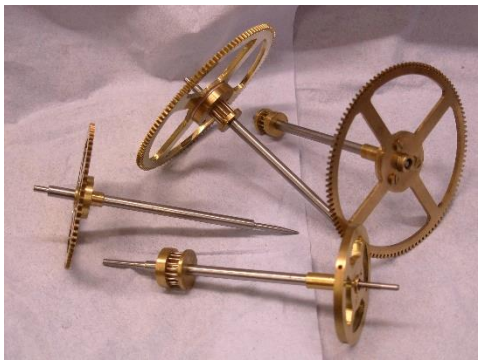


The next slide is a ‘Perpetual Calendar’ mockup for the clock above. Richard looked in books, and took some ideas from Rawlings, but he wasn’t sure it would work. This is a mockup made from bits of MDF and plywood. There is a cam, which rotates once a day and pushes a lever. This small wheel (top left) has seven teeth, so every time the lever goes back and forth, it moves on a day, displaying the days of the week. The other wheel (left) has thirty one teeth, so every time the lever goes back and forth, the ratchet pushes it on a day. When it has done a month, there is a tripping peg which makes the small wheel (centre) go around one tooth. There are twelve teeth on this wheel, and this is attached to the months of the year. The arrangement with the slots on the outside is a four-year cam, or a mechanical computer. On the outside, because it is four years, there are indentations which represent 30 days in the month. The deeper indentations represent February. There is one with a slightly less indentation which is the leap year. The calendar, if everything is working as it should, will keep the date constantly including leap years. It does work, but it is not perfect, and Richard is still working on it. It was made actual size.



This is not one of Richard’s clocks. This is an American ’Seth Thomas’ clock which is late 19th century/early 20th century. All the gears will be pressed out of brass. The escapement is just a piece of bent spring steel. It is very simple and very cheap to make. Richard showed this slide because all clocks are just a gearbox, consisting of a front plate and a corresponding backplate, and between the plates are all the gears and pinions. The time keeping gears are on the right-hand side, along with the drive spring and the winding mechanism. On the other side is the alarm mechanism. There is a tripping lever on the pointers which allows the alarm to go off. The bell and hammers can be seen. Although the clock looks complicated it’s not. The two gear trains are completely separate, apart from the time linked with the lever.

This mechanism of Richard’s is an ‘epicyclic gearing’ inside the clock. This is maintaining the weight energy on all the gearing, as the winding process is taking place.



Gears (clock makers call these wheels) and pinions. These are out of Brian Stephenson’s ‘Congrieve’. The pinions have little pins in them, and they are called ‘Lantern’ pinions. In the early days of clock making, it was easier to create pinions in this way, than cut the teeth with a cutter. Pinions should be made out of hardened steel, and to cut pinions you need a good cutter. With pins, you could get wire that was already hard. The pins fill the holes on a PCD, and they are then snipped off and let in. An automatic hardened pinion is then created. This works quite well

When the gears have been made, the right centres have to be found to plant them on. Centre distance of clock gears is very important because of friction. If they are not right, too much friction can be generated, and a lot of energy wasted, so the spring will not drive the escape wheel. A clock is back to front to a normal gearbox. In a gearbox the motor is put onto the pinion and the speed is reduced. In a clock it's the other way around. All the energy is put into the gearing which drives the hand that goes around once a day. Also, the hand that goes around once a minute has been geared up. That is a high ratio, and a lot of friction is lost. The normal way to get the right centres is to use a tool which sets out the centre distances for the gears. The gears for Brian's 'Congrieve' were too great for Richard's tool, so the simple way was to set them up on the milling machine. The gear was put in the vertical head, the pinion in the rotary table, and the table was moved so the pinion was engaged, looking at the engagement with a magnifying glass to make sure it was right. Then the distance between the centres was measured. That gave the exact centre distance. In engineering, the centre distance is established first, and the gears are made to fit, then the teeth etc are measured, so when it is assembled it will be correct. With clocks it is not quite as simple, and the requirement is that the best engagement must be achieved. It is therefore best to make the teeth first and the centres of the gearbox set out later.

This is a kitchen clock that Richard made, with a pendulum movement, similar to the ones shown earlier. This has a case with a painted dial. It is unusual as some of the numbers are radial and some are tangential. Richard met someone in Scotland who was a curator of The Glasgow School Of Art, which was designed by Rennie Mackintosh. The School of Art had a master clock in the office, and all the slave clocks were in the classrooms. Rennie Mackintosh designed these types of dials because he wanted to reflect his 'Arts and Crafts' activities. Richard decided to copy that. These dials are known as 'Tumbling Chapters'.

44crutch 3G.MOV

The next video is a magnified 'slow motion' video of a pendulum, where the pendulum rod works onto the 'crutch' of the clock. The size of the rod here is 5mm (3/16"), and there is a slight working gap between the 'U' shaped 'crutch' lever, and the flats on the pendulum. The pendulum needs energy to keep it swinging in time. This is what is happening here. Although the pendulum, is actually operating the escapement of the clock, the escapement is feeding energy back into the pendulum. It gives it a little tap, here and there, while it is going across. That is coming back from the spring, all the way through all the gears, through the escapement, just to tap the pendulum and keep it going.

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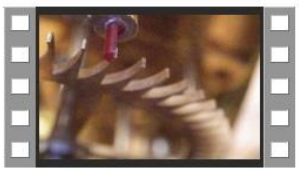
https://www.youtube.com/watch?v=sFLQ2I-B_wY



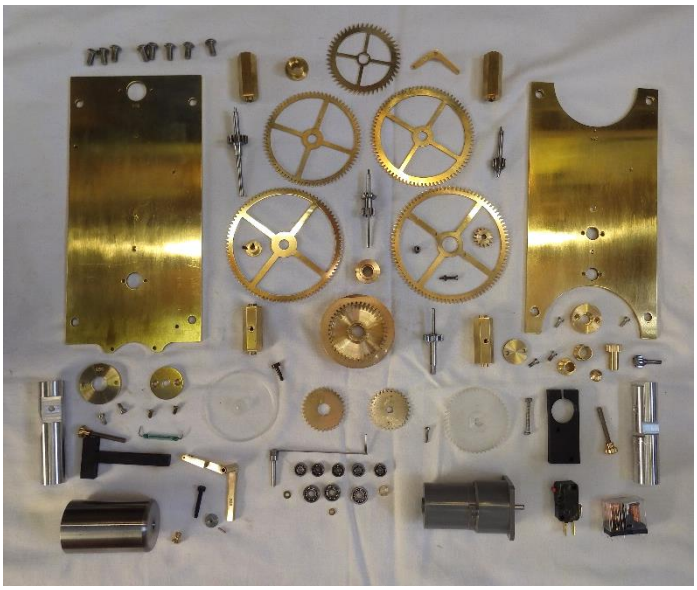
41escapement G3.MOV

This video shows the escapement:

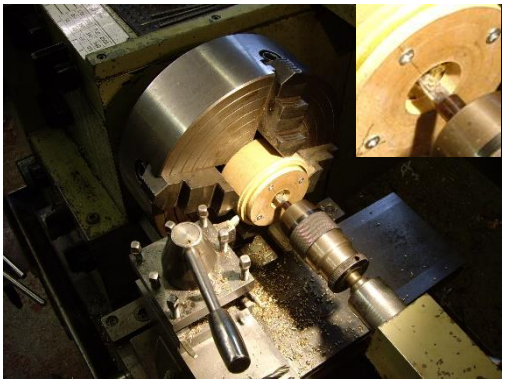
Please press on this link to see the video:
https://www.youtube.com/watch?v=nVSIIHakjcM

The size of the pin is about 2mm, and it is an artificial sapphire. These can be bought and they are reasonably priced at about £ 8 - £9 each. They are brittle so they have to be treated with care. This video is an illustration that clocks actually stop every time the pendulum swings backwards and forwards. All the gearing stops and the weight is hanging waiting, or the spring in tension is waiting, to be released for the next tooth to go around. This is a very 'stop/start' operation. That is why friction is so important, because starting something off takes more power than when it is running. A clock has to be as frictionless as possible. The jewel escapement is rubbing on the teeth so there is a friction there, but friction between the sapphire and the brass is low. Jewels running on brass or steel have lower friction than steel on brass for example. The jewels must be polished. The energy is given to the pendulum, as can be seen, as the pin engages in the teeth, and stops the tooth going around. As it

slides off and slides around the rounded part at the bottom, that has the action of pushing up the escape arm and transferring it through the ‘crutch’ and giving the pendulum a tap. Note: Obviously this mechanism is duplicated on the other side of the clock.



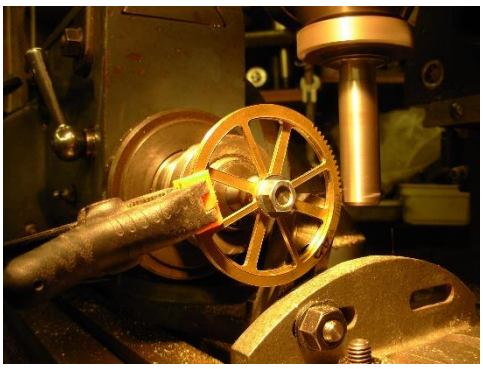
This slide shows all the bits needed to make up one of Richard’s clocks. There is one escape wheel (the one with pointed teeth at the top), gear wheels, the internal gear wheel, its drive motor, and ball bearings. As Richard did not have a lot of clockmaker’s hand tools when he started making clocks, he wondered what he was going to do about pivots, where the axles (clockmakers call these arbors), go through the front and back plates. Bearings, were an obvious choice, as they had been used in clocks before. Holes are reamed out in the plates for the bearings, and the arbors, are turned down to fit the bearings. The one thing about bearings is that they usually come with shields, and are packed with grease or heavy oil, which is unacceptable for clock use. The first thing to do is to prise out the shields and throw them away. The grease and oil is then washed out of the bearings with white spirit, which leaves an oily film on the bearing. The bearing should then be put on the end of a rod and spun with a finger. It will spin for several seconds as it has low friction. A ball bearing has rolling friction rather than rubbing friction, and rolling friction is less than rubbing friction. As can be seen in the picture, some of the arbors are bearings and some are just tiny balls, Richard found that the further up the gear train the ball bearings are, the more susceptible they are to dust in the atmosphere, and several other factors, and sometimes they seize up. All clocks should therefore be free from dust and the elements, and the cases sealed up for protection.



The following pictures show some parts being made. On Richard’s big Harrison 300 lathe, there is a block of MDF in the chuck, and the plate of the gearwheel in brass, has been turned down. A reamer is being pushed through the centre hole, and by doing that, the outside and the hole in the middle are concentric. This is very important in clock making, as the teeth must not vary in depth.

Here a square of brass has been trepanned out with a trepanning tool, to get a blank. The blank has already been ‘crossed out’, taking a lot of weight out of the middle of the gear. Richard believes that it is good practice to take all the ‘meat’ off first, rough it out then finish it because it stress relieves itself. However, most clockmakers will tell you to do the blanks first, then cut the teeth, and then take the metal out (crossing out). Richard prefers it the other way around

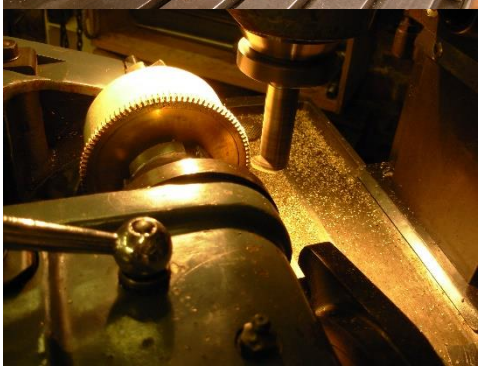
Making gears on the milling machine. A pinion is being made here. The picture shows the dividing head, the vertical head of the mill with a fly cutter. Teeth are being milled out of silver steel. In this case the tail stock is up for help.



Here the wheels are being made. The bulk of metal has already been taken out of the middle, and the teeth are being cut. As the metal has been taken out, the wheel is quite flimsy, so there is a backup piece on an angle plate to take the fly cutting forces. This is a plastic clamp to stop it vibrating. It is important to get the inertia down on wheels so they run as efficiently as possible in the clock, and that is why they should be as light as possible.

Cutting brass internal gears. This is normally done with a slotting machine, or a slotting head on a vertical miller. This is a different method. The dividing head with the chuck and the work, can been seen. The vertical head has been angled over at about 60°. There is the 'T' cutter, (which was made in a lathe out of silver steel), turned to the required profile, taking into account the 30° angle that the cutter is at, so it's like an elongated cutter. Richard machined it exactly down its middle, halfway, hardened and tempered it, and then cut the teeth. They are only about 3/16" face width, so it's not a great depth of cut. There's not much travel available, but the head will rotate and go up and down to make the full cut in one go.
As mentioned above, the cutter is hardened silver steel. Hardening is relatively easy, and the temperature doesn't need to be controlled. It just needs to be heated up until it's red hot, quenched in water, and given a polish. It is then tempered by warming it up gradually to a temperature which gives a colour on the steel, between 'pale straw' (the hardest) and 'deep blue' (the softest).

This shows another pinion being made using a fly cutter, with no support on the nose. Like all good model engineers, you start with a blank and you try and fashion as much of the component as possible, before parting off. Here there is a good solid blank in the collet.



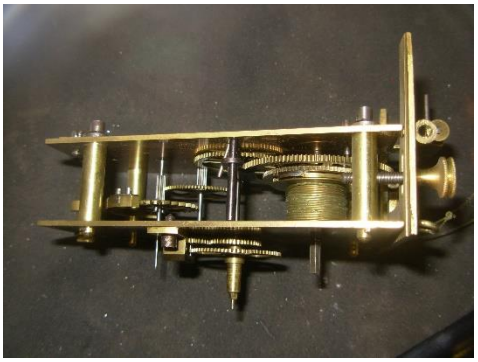
These two pictures show more gear cutting, using a fly cutter. Here the brass is backed up with plywood or MDF. It is, however, not glued to the MDF, but it can be. When turning small components, what used to be done was to use melted Shellac to stick components onto a chuck, in order to work on them in a lathe. Nowadays there is superglue. The way to get super glue off is to heat it up. If the component is stuck onto MDF, care is required, when heating up. Double sided tape could be used, but Richard doesn't find it rigid enough, and also glue can get into and mess up the cutters.

This is showing cutters being made. The cutter can be seen, and also the lathe tool which will be used for the profile of each tooth on the cutter. The gaps between the cutter teeth have been taken out, and there are ten teeth on it. The following video shows how it works:
Please press on this link to see the video:
https://www.youtube.com/watch?v=BXsHnyZOW50&t=3s

Again, this is the Harrison 300 lathe. Here the cutter is being indexed. The motor/gearbox arrangement is simply to provide the rocking motion. The lathe itself is switched off, out of gear, and declutched with no drive whatsoever, so the headstock can rotate backwards and forwards. A multi-tooth milling cutter is being made here. The arbor has an eccentric nose on it to which there is a pin to index the milling tool around each time. The wheel is mounted at right angles to the cutter. The milling cutter is going to be used to manufacture escape wheels.

This an 8mm Pultra watch and clockmaker's lathe. A pivot is being polished with emery cloth, and the axle/arbor is being held in the collet. There is also a brass steady block with holes in it.

This is a Turret clock at the BHI museum. The gear is about two feet in diameter, and the big dials in towers used to have these behind. They are very robust, and heavy. The pendulums are enormous, the one in Big Ben weighs about a quarter of a ton. The reason that they are heavy and robust is because accurate time was wanted, so the mechanism had to be engineered. Wind blowing through the turret and variation in temperature, required a steady mechanism, so they went for the heaviest they could engineer. The escapements are either 'dead beat pins and pallets', or gravity escapements that keep good time. Nowadays, an electric drive is put in, governed by the atomic clock in Cumbria. Some turret clocks are being saved. The clock in Ganton church now has an electric rewind. Some of the turret clocks have been fitted with electric type regulating mechanisms.



This picture shows the movement of a Vienna clock. The simplest Vienna didn't have any chiming or strike, and there was just one gear train. It was weight driven, and the cat gut on the drum can be seen. The escapement is 'dead beat'. These are good clocks to start on for a new starter.

The pendulum on the Vienna had snapped, and Richard's first challenge, when he started on clocks was to repair it. The pendulum is wood. Wood, surprisingly doesn't expand very much with heat, so the time of the clock is fairly accurate.

After tea, Richard, showed us a hand tool for getting centre distances correctly, a 'crossing out' template, and he also gave a demonstration of a wheel cutting engines. There was also a lively discussion during the demonstration. All of this can be seen by clicking on the following videos :

Richard Explains 1.AVI

Richard Explains 2.AVI

Wheel Cutting Engine.AVI

Richard Explains 1: https://www.youtube.com/watch?v=w9a5ZoUGYdo

Richard Explains 2: https://www.youtube.com/watch?v=9yCVkgcJxQQ

Wheel Cutting Engine : https://www.youtube.com/watch?v=MRZw4RsVdOA

(Acknowledgements to Richard for proof reading this article)

A PEEMS Visit To The JCB Headquarters At Rocester Staffordshire On The 12th December

At 8.00am on a freezing cold Tuesday morning, PEEMS members and guests, numbering twenty seven souls, boarded a coach at Mike's, to travel one hundred and thirty nine miles to the JCB headquarters at Rocester in Staffordshire.
When they arrived at the VIP Visitor's Centre, they were treated to a welcome meal of cottage pie, crème brûlée, dark chocolate mints and coffee. Overseeing their meal was the 70th Anniversary 3CX JCB, seen above. JCB's 70th anniversary was in 2015, and as is explained later, this is the age of the current Chairman, Lord Anthony Bamford. JCB was founded by his father Joseph Bamford, when Anthony was born. The 3CX JCB has a 31KW (109 hp) Stage 4/Tier 4 Final Ecomax engine, 6 speed autoshift transmission with torque lock, and a high spec airconditioned cab with a heated air suspension seat and coffee making facilities. The 3CX was resplendent in its 70th anniversary livery, based on the classic 3C Mk III.
The day consisted of 4 events: the meal, a guided tour through the 'Story Of JCB' exhibition, a guided factory tour and finally a return to the Visitor's Centre for coffee, biscuits and 'Quality Street' chocolates.

- **The 'Story Of JCB' Exhibition**

The 'Story Of JCB' exhibition traces the history of the Bamford family from the 1820s to the present day. For the tour, the group was split into two, given Hi-Viz jackets, safety specs, and receivers/head phones so they could hear the two guides, Les and Gordon. The first place visited was the theatre for a safety briefing. As the stairs were climbed to the theatre, some of Joseph Cyril Bamford's famous quotes could be seen emblazoned on the walls, such as: *"Jamais Content – That's Very Much Me. I'm Never Content"* and *"Problems Are Only Solutions In Disguise".*
The two hundred seat theatre is used to launch products to the press and customers, and when the curtains were pulled back, the star on stage was an 86 C-1 ECO midi excavator.

The ‘Story Of JCB’ exhibition is split into various zones. These are:

- The Early Years
- Building A Brand
- Design and Innovation
- Global Expansion
- Mr JCB’s Office
- Heavy Products
- Agriculture
- Worldwide Support
- JCB Diesel Max
- Government and Defence Awards and Family
- ECO Responsibilities.

- **The Early Years.**

The ‘Early Years’ traces the story from the 1820s, when the Bamford family were blacksmiths in Uttoxeter. They then became Bamfords Ltd, a firm of agricultural engineers. The director Henry Bamford (Joseph’s father’s cousin), sacked Joseph Cyril Bamford by sending him a note saying that “his services would no longer be required”. Joseph, however was very entrepreneurial and formed his own company JCB after the war in 1945. The rest is history.
Numerous products from the Bamford years were on display, and the following are examples :

Grain Crusher

Cheese Press (1860)

Straw Chopper

The exhibition then continued to the founding of JCB in 1945.

The photograph above was taken in 1947, and shows Mr JCB holding two year old Anthony. They are standing in front of one of the company’s first all steel tipping trailers. Apprentice Bill Hirst is seen on the left. Next to Bill is Arthur Harrison, who as first foreman, ran the machine shop, next to him is Bert Holmes, JCB’s first welder. Bill retired as Director of International Service Standards in 1991.

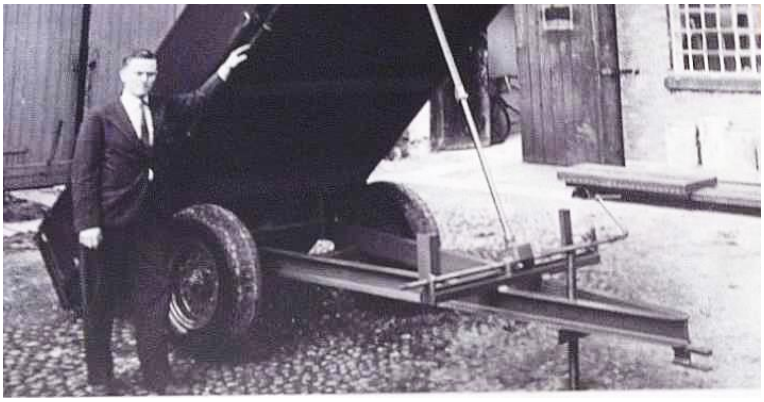
JCB started in 1945, and was founded on Anthony Bamford's Birthday.

Shown opposite is a replica of the lockup garage in Uttoxeter which Joseph rented. It was 3.7 by 4.6 m (12 by 15 ft).

Inside can be seen an early hydraulic all steel tipping trailer (1948), which was revolutionary because it allowed the operator to tip the load from the tractor seat.

To the left of the trailer can be seen JCB's first welding set.

The first trailers JCB made in 1945, were manufactured using steel that was produced by straightening out the corrugations of war surplus steel Anderson air raid shelters. The first trailer made is exhibited in the entrance to the technical block.



This first trailer was manufactured in the lockup garage, and was sold at Uttoxeter town market for £45. Mr Bamford took the buyer's cart in part exchange, refurbished that and sold it for another £45. Decades later the trailer was discovered working locally. It was dilapidated, but in good working order, and the company bought it back for substantially more than £45, and refurbished it back to its former glory.

- **Building A Brand**

The next section deals with how JCB built their brand. During the late 1950s, JCB branded its products, by the use of brilliant yellow and red livery, and the introduction of the famous JCB logo. On the floor we could see the first Mark 1 Backhoe (a mechanical excavator with an extension consisting of a bucket on an extending arm).

The Mark 1 (1953) sparked a revolution in the excavator industry, by combining two functions on the same machine, loading at the front end and digging at the back. It transformed the way in which the world would be built.

The Mark 1 has a 180° swing, long reach and deep digging capabilities. It gave the operator previously unheard of flexibility and control. It had square hole digging capability.

Performance/Engine Power:	36kw – 45 bhp
Transmission:	Manual 4 speed
Excavator Dig Depth	3.35 m – 11 ft
Excavator Reach	4.57m – 15ft Excavator Bucket
Tear Out	4,536 kg – 10,000lbs

Two lever operation for ease of use of loader.
Five lever control for backhoe.

Machine based on a Fordson tractor unit.

550 units were sold between 1953 and 1957.

Also in this section was the JCB SI-Draulic Loader (1953) for lifting hay bales and similar.

This was a simple attachment that bolted to a farmer's own tractor. Its heavy duty single arm offered great strength and flexibility, and could be detached in 2 minutes, by the easy removal of two pins. The high lift and long forward reach was unattainable by more conventional competitors.

All for the princely sum of £75.

Subframe:	Bolted to the axle and supported by suitable braces.
Jib:	Single 114mm (4.5") tube braced with a tie rod.
Cylinder Lift:	One only gives 762 kgs (1,680lbs)
Tearout:	1,270kgs (2,800lbs)

A field fit loader for Fordson and Ferguson tractors

Approx 6,000 units were produced by JCB.

20,000 units produced under license.

Sold with muck fork attachment.

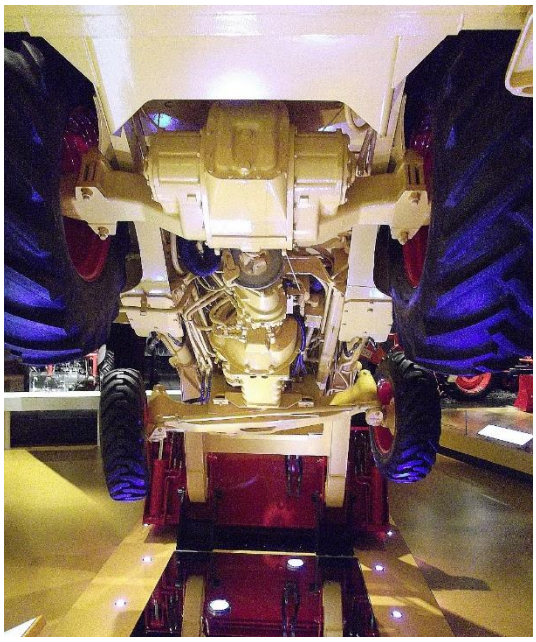
The JCB 3 Back Hoe Loader (1961) was the forerunner to the famous JCB 3C introduced in 1963.

The JCB 3's 180° side shift backhoe allowed the house builder to work hard up against a wall for the first time. Due to its standardised hydraulics and three-in-one bucket, it could also dig perfectly square holes, up to three metres deep.

Performance/Engine Power:	38.1kw – 51.8 bhp
Transmission:	Manual 4 speed
Excavator Dig Depth	3.04 m – 10 ft
Excavator Reach	4.75m – 15ft 7in
Excavator Bucket Tear Out	5,216 kg – 11,500lbs
Loader Forward Reach	1.07m – 3ft 6 in
Loader Lift Capability	2,.086 kgs – 4,600lbs.

Fitted with a 'Hydraslide' kingpost for digging up to a wall. The stabilisers were an extra safety feature, as the driver enters through the back. The integral chassis construction includes hydraulic and fuel tanks. There was also a two lever control to reduce operator fatigue.

The JCB 3C MK 3 Backhoe Loader (1977) in the classic 'dancing digger' mode. The 'Up and Over' stunt was first presented for Lord Bamford's 25th birthday in 1970. The JCB 3C MK3 was the last in the series and was fitted with JCB's own power train, gear box and torque converter. The 'dancing' mode, allowed visitor inspection of the power train.



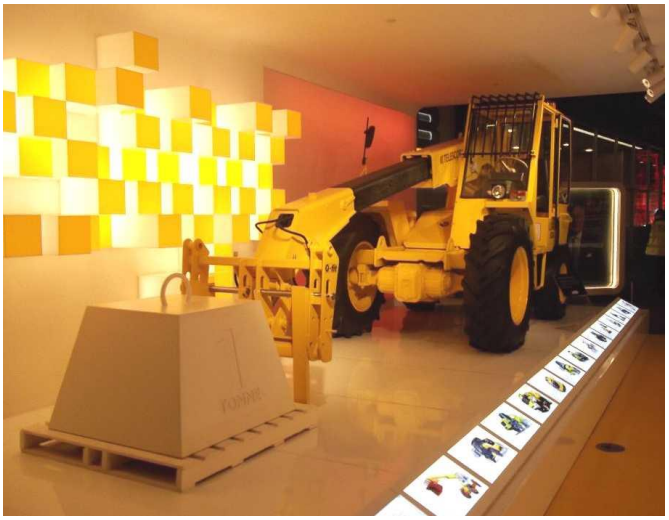
- **Design and Innovation and Global Expansion.**

The centrepiece of this section was 'The Patent Vault' in the floor. From 1945, nearly 1,000 patents have been issued to JCB.

Mr JCB's office, was in this section. In 1975, Mr JCB announced his retirement, and his eldest son Anthony took over as Chairman at the age of 30. The refurbished Joseph Bamford's office is now used for VIP meetings.

On display were:

- The 110B Crawler Loader which was produced in the early 1970s with many world firsts.
- The 520-4 Telescopic Loadall. This came out in 1977, and JCB led the way with the telescopic handler concept in Europe.



JCB 520-4 Telescopic Loadall Handler (1981)

This is a rough terrain fork lift truck with a telescopic boom. It could reach up, forward, over and through, enabling it to lift loads of all types, and place them with safety and precision, every time. Its low height allowed it to enter workshops, pass through doorways and low obstructions. It is 4 wheel drive.

Performance/Engine Power:	54kw – 72 bhp
Transmission:	4 speed synchromesh With powershuttle reverser
Forward Reach	3.65 m – 12 ft
Lift Capacity	2,000kgs - 12,083lbs
Maximum Speed	24kph – 15mph

JCB 110B Crawler Loader (1972)

The first machine of its type in the world, the 110B introduced a whole new way to shift dirt and lift heavy materials. The model offered fully hydrostatic transmission, superb visibility from the front mounted cab, and smooth automatic and speed adjustment.

Performance/Engine Power:	58kw – 78 bhp
Transmission:	Fully Hydrostatic
Forward Reach	2.02m- 6ft 8in
Lift Capacity	2,903kgs – 6,400lbs

Simple three lever loader controls
Six-in-one front shovel for multi-purpose operations

The JCB 110B Hydrostatic Crawler Loader ~ Serial Number 80522 was built in 1973, and spent the first part of its life in the JCB demonstration fleet, conducting dealer demonstrations around the U.K. The design was a departure from the norm in that conventional crawler design dictated that these machines were built on a tractor skid unit, placing the cab at the rear of the machine, with the engine in front. This meant that the operators view of the bucket was impaired, complex levers and foot controls meant that these vehicles were difficult to operate. The 110B by comparison, used hydrostatic drive pumps and motors driven by a rear mounted engine, which allowed the cab to be mounted in the middle, providing excellent forward visibility. Twin lever controls eliminated the need for foot pedals. Both track and loader levers could be operated with two hands making the machine operation quick and productive. In 1977 this machine was driven by HRH The Prince Of Wales. 80522 was rebuilt and placed in the JCB historical vehicle fleet.

- **Heavy Products and Agriculture.**
  JCB has its roots in agriculture, as has been seen with Bamfords of Uttoxeter, and on display were:

  - The JCB Loadall 515-40 (2011). This is the smallest in the JCB material handling range, but which can still lift a weight of 1.5 tonnes to 4 metres (13ft 1in). It has an off-set single spine chassis, which has its core strength under the boom and wraps around the cab. This allows for a safe and comfortable cab in a machine standing at 1.84 metres (6 ft) high. This vehicle allows operations in buildings with restricted height like cattle and poultry sheds.
  - JCB FASTRAC AC 3000 Series Tractor Chassis and Power Train (1991). This was revolutionary when it was launched in 1991, the latest Fastrac remains the most advanced tractor on the market. With full chassis construction, a unique front and rear suspension design and ABS controlled disc brakes, it is powerful, fast and efficient in the field. It is capable of road speeds of 80 kph – 50mph.

The JCB Loadall 515-40 (2011).

Performance/Engine Power:	38kw – 50 bhp
Transmission:	2 speed hydrostatic
Forward Reach	2.45 m – 8 ft 6in
Lift Capacity	1.5 Tonnes (1.65 tons)

Permanent 4 wheel steer and 4 wheel drive

JCB FASTRAC AC 3000 Series Tractor Chassis and Power Train (1991)

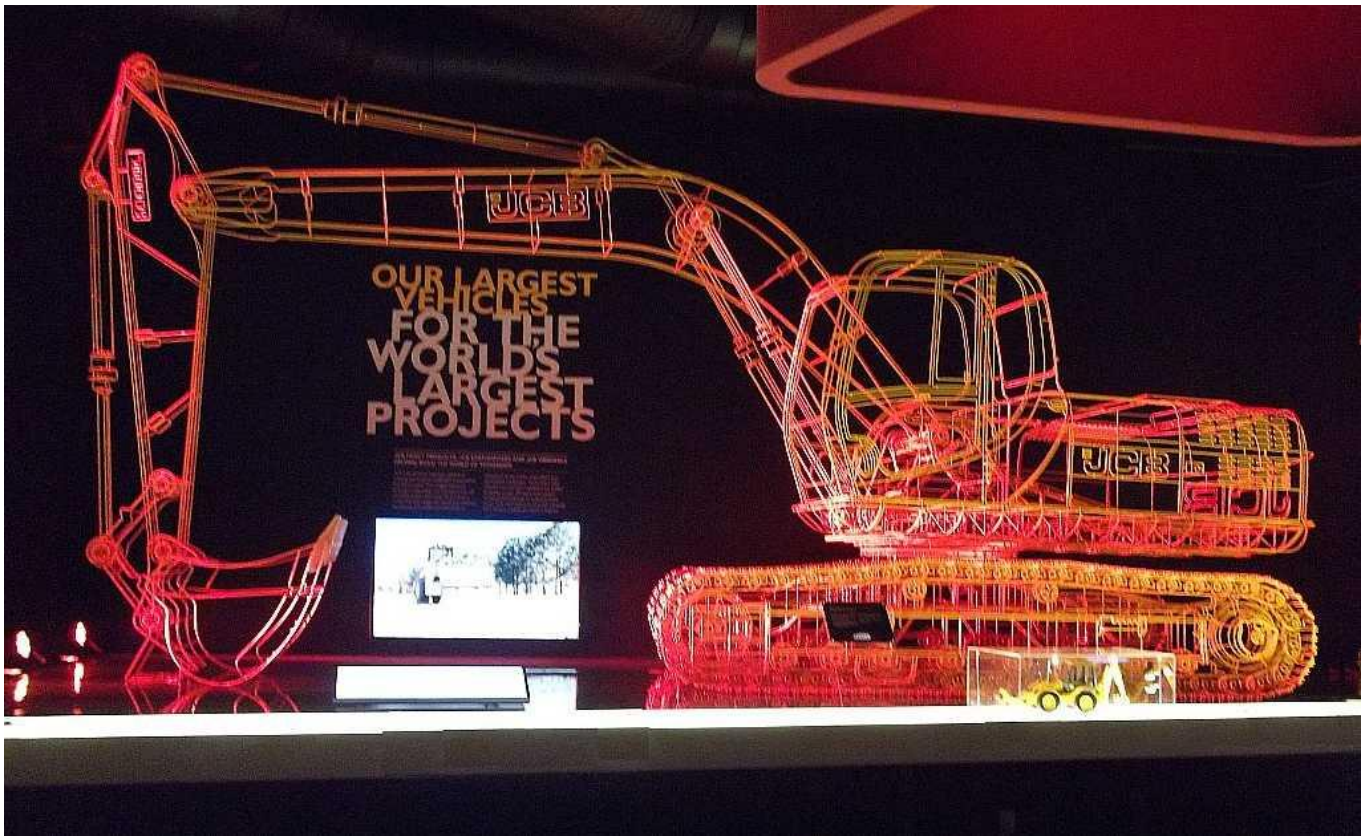
Performance/Engine Power:	191.2kw – 260 bhp
Transmission:	semi powershift 24 fwd 9 rev gears.

Capable of road speeds up to 80kph - 50mph.
Hydraulic self levelling rear suspension system.
Anti Lock braking system – air over hydraulic.
Electrohydraulic spool valves for various implements.
Rear load deck will carry a 2,000 litre sprayer.

JCB Heavy Products is the home to excavator manufacturing in the UK. The factory designs, develops and has the capacity to produce up to 8,000 tracked and wheeled excavators every year.

JCB Earthmovers produces the JCB range of wheeled loaders renowned for their power to weight ratios.

The Heavy Products were represented by a 2 ton sculpture of an excavator, and all the parts work. This was created by Benedict Radcliffe using 8mm bar. It took three months to build.



- **Worldwide Support.**

8018 Utility Mini Excavator (2010)

This mini excavator was designed in close co-operation with UK Ultility companies.

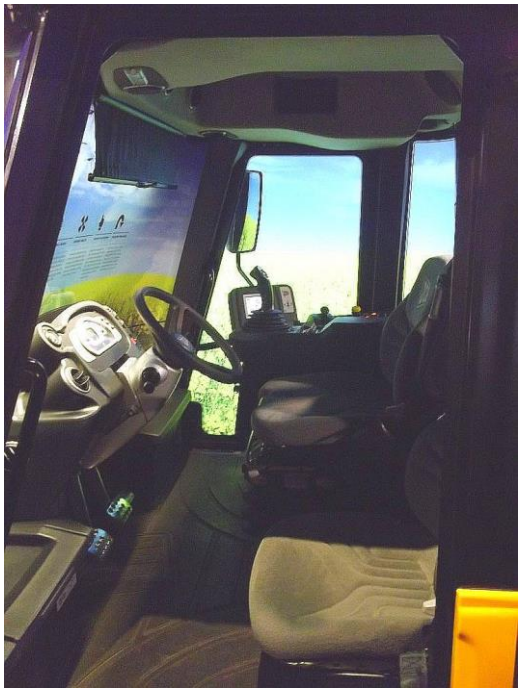
The 8018 is an innovative solution to the potential hazards and operator demands in this hard-working market sector.

Here it is seen in its optional high visibilty livery.

Performance/Engine Power:	14.2kw – 19.7 bhp
Transmission:	Fully hydrostatic
Forward Reach	4.2m – 13 ft 11in
Excavator Dig Depth	2.8m – 9ft 1in
Tear Out:	1,652kgs – 3,642 lbs

Rugeley based JCB Cab Systems Ltd have been building cabs for the JCB product range, supplying the UK based plants in Rocester, Uttoxeter and Cheadle. The company produces cabs, ranging in size from 1 meter wide for micro machines, to 2.5 meters wide for the largest diggers. Each cab is fabricated and assembled to suit the individual build requirements of each JCB plant. The cabs come on to site fully provisioned.

Here we can see a PEEMS member 'driving' a cab :



The next two vehicles were the warehouse crate lifting fork trucks :

- The 260 T ECO Skid Steer tracked vehicle. The 260T has unique side door for safe entry. It has a much larger cab than any competitor, and it offers good visibilty (270°) and low operating costs.
- The Teletruk 30D 4X4. The 30D has the small footprint of an industrial fork lift, and the boom of a telescopic Loadall. It features a fully enclosed hydrostatic drive system and an ATA class 3 carriage for any class 3 attachments. Available with diesel or a gas powered engine unit. Single stage telescopic boom.

Teletruk 30D 4X4	
Performance/Engine Power:	47.7kw – 57.6 bhp
Transmission:	Hydrostatic
Forward Reach	2.4m – 7 ft 10in
Lift Capacity	3,000 kgs – 6,600lbs

260T Eco Skid Steer	
Performance/Engine Power:	63kw – 84 bhp
Transmission:	Hydrostatic
Forward Reach	1.21m – 4 ft
Lift Capacity	1,179kgs – 2,600lbs

- **JCB Diesel Max**

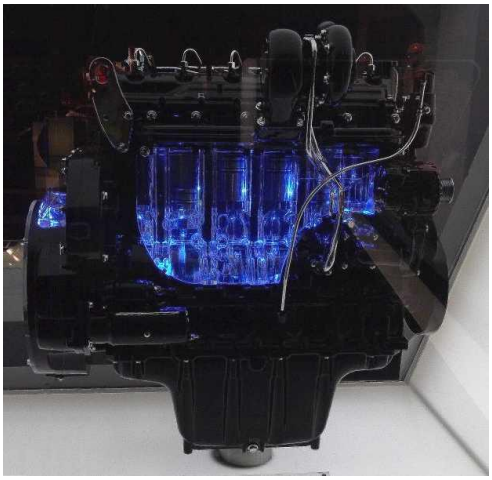
The latest engines meet Tier 4 legislation, while providing fuel efficiency, without the requirement for 'after treatment', an industry first.

The DIESELMAX Streamliner car broke the world land speed record for a diesel powered car at 8.38am on August 18th 2006, at the Bonneville Salt Flats, averaging 510.196 kph (317.021 mph), using a standard engine configuration. On August 23rd the car achieved 563.418 kph (350.092 mph).

The engine is now used to power JCB's backhoe loaders, Loadall telescopic handlers, JS excavators up to 20 tonnes, rough terrain forklifts, and small loading shovels.

The world's fastest diesel powered car is driven by two JCB Dieselmax 444 common rail injection diesel engines, each delivering more than 750 bhp and 1,500 Nm of torque. Each has twin compound turbochargers and intercoolers. The forward transmission and final drive is connected to the forward engine, and the rear transmission and final drive unit is connected to the rear engine. Bringing the Streamliner to a halt are three separate braking systems, parachute, exhaust and wheel disc brakes. The car was driven by Wing Commander Andy Green who broke the land speed record in 1997 taking Richard Noble's Thrust SSC to 763mph, becoming the fastest man on earth. For more details, click on this link: http://www.jcbdieselmax.com/index.html

JCB Engines



JCB Dieselmax 6 Cylinder 7.2L

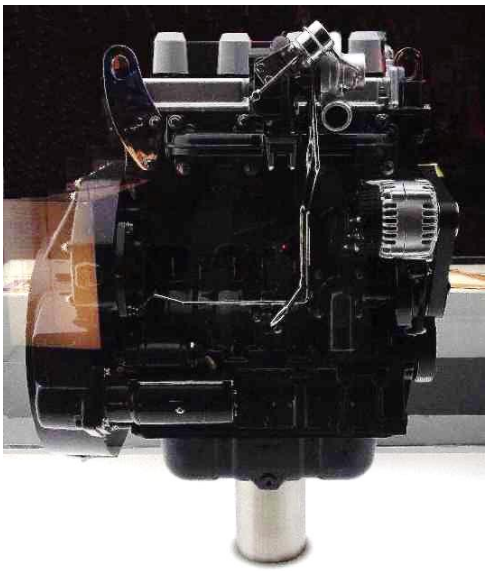
The 6 cylinder version of the JCB Dieselmax 4.8L engine is rated up to 300hp and offers high torque at low speeds. It is designed to match the requirements of JCB's heavy line machines. It has very low fuel consumption (190g/Kw hr) and exceptional reliability and durabilty.

Min Rated Power	140 Kw – 188 bhp
Max Rated Power	225 Kw – 300 bhp
Emissions Cert.	Stage II, Tier 2
Rated Speed	2,000 rpm
Peak Torque Speed	1,400 rpm
Peak Torque	1,200 Nm

JCB ECOMAX T4 Engine

JCB Ecomax T4 Engines feature an advanced combustion system that gives very low emissions and fuel consumption. With the use of cooled EGR, a common rail system operating at up to 2,000 bar and a variable geometry turbocharger, the JCB Ecomax T4 does not require a Diesel Particulate Filter.

Min Rated Power	55 kW – 74 bhp
Max Rated Power	129 kW – 173 bhp
Emissions Cert.	EPA Tier 4, EU Stage 3B
Rated Speed	2,200 rpm
Peak Torque Speed	1,200 - 1500 rpm
Peak Torque	400 - 690 Nm
Low Idle Speed	850 rpm
Engine Size	4.4 Litres
Engine Cubic Capacity	4,399 cc

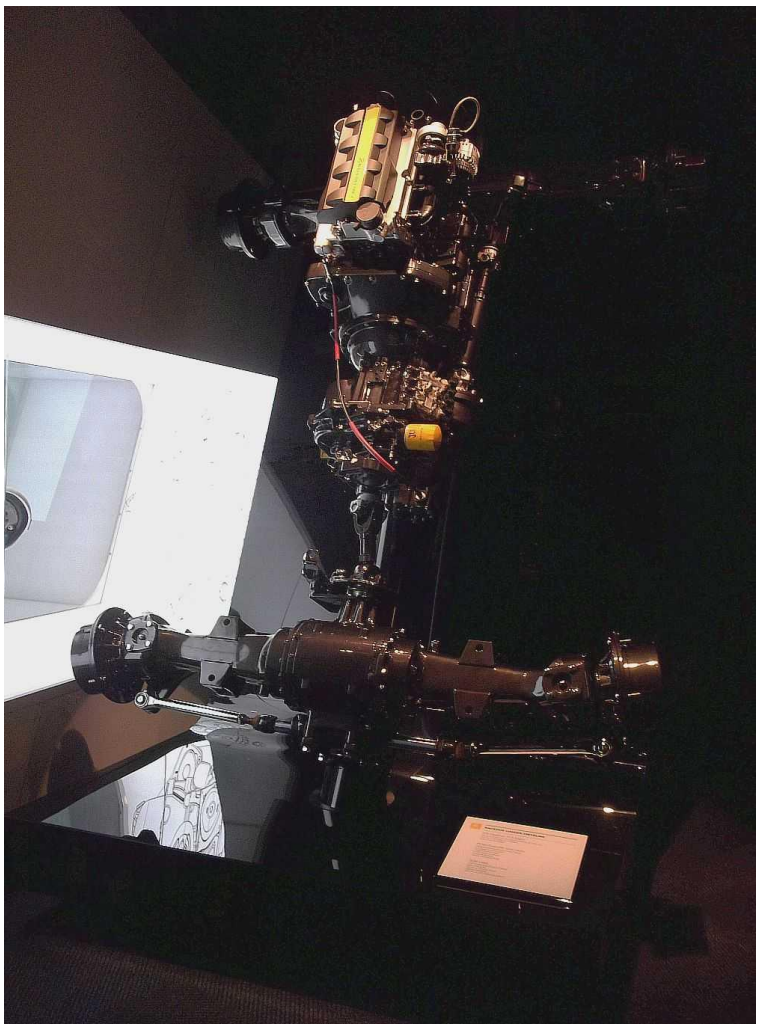


JCB Dieselmax T3 Engine

The development of the Dieselmax engine is typical of JCB innovation. Starting with a clean sheet of paper, its simple design – aimed specifically at mid range off-highway equipment - gives it exceptional performance, high power high torque at low revs with low fuel consumption and low noise (89 dBA).

Min Rated Power	63 kW – 84 bhp
Max Rated Power	120 kW – 161 bhp
Emissions Cert.	EPA Tier 3, EU Stage 3A
Rated Speed	2,200 rpm
Peak Torque Speed	1,200 - 1500 rpm
Peak Torque	362 - 657 Nm
Low Idle Speed	850 rpm
Engine Size	4.4 Litres
Engine Cubic Capacity	4,399 cc

The JCB Backhoe Loader Driveline



JCB Dieselmax TCA Engine

100hp (74.2 Kw) AND 114 HP (85 Kw) Ratings @ 2,200 rpm.
USA Tier 3/EU 3A Compliant.
Internal EGR Technology.

PS760 Powershift Transmission

590 lb-ft (800 Nm) Maximum Input Torque.
4/6 Speed Forward Gears.
4 Speed Reverse Gears.
W300 Torque Converter.
Coaxial Pump Drive.
Internal Wet Parking Brake.

SD80 Axles

17637 lb (8,000 kg) Dynamic Loading
Steer Drive Axles
Pad,Pin or Trunnion Mount
Optional Parking Brake
Max Trac or LSD Differential Options

- **Awards**

JCB has won more than 70 major awards for engineering excellence, exports, design, marketing, management and for its care for the environment. Over the years JCB has received numerous awards including the Queen's Awards for Innovation, and Export, Design Council Awards, and British Quality Awards.

And Finally…..

- **ECO Responsibility.**

The JCB 3CX ECO SITEMASTER (2011)

Designed for today's energy conscious world, the 3CX applies innovative technologies to reduce the cost of ownership. Features include: EcoDig, a three pump hydraulic system for greater fuel economy, Ecoload for faster lifting with hydraulic speed control for greater traction, EcoRoad, reducing fuel consumption by up to 25% via the JCB Torque Lock system.

Performance/Engine Power:	68.6 kw – 92 bhp
Transmission:	4 speed Powershift
Excavator Dig Depth	4.75m – 17ft 11in
Excavator Reach	7.87m – 25ft 10in
Excavator Bucket Tear Out	6,228 kg – 13701 lbs
Loader Forward Reach	1.15m – 3ft 9 in
Loader Lift Capability	3,169 kgs – 6,986 lbs
Maximum Speed	38 kph - 23 mph.

The Union Jack Backhoe.

Flying the flag for British manufacturing, this JCB 3CX was prepared in patriotic style to mark the launch of the latest fuel efficient backhoe loader. The new generation of machines offer fuel savings of up to 16%.

The fuel savings are derived through the introduction of a new hydraulic system which utilises three hydraulic pumps instead of two, providing the same hydraulic output, but at a lower engine speed. The introduction of power brakes also contributes to the fuel savings.

A replica of this distinctive machine was auctioned to support the 'Help For Heroes' campaign, the British charity that supports servicemen and women wounded in conflicts around the world. The Ipswich based hire firm 'Fork Rent' secured the machine with the highest bid of £70,250.

- **Factory Tour**

After 'The Story Of JCB' Exhibition, the tour groups visited the factory and technical offices. Because of time constraints, only one production line could be visited, in the case of Les's group, that was the 'Backhoe' Loader.

Rocester has been the main HQ since 1950. JCB does not directly sell Telehandlers or Backhoes, all sales are done through dealers.

Les's group first visited the Hydraulic Rams Unit. All the raw materials and castings are bought in and machined on site. The group saw how hydraulic ram eye ends were friction welded to the shafts. Castings come from Fiat in Italy, through the Brenner Pass. The group inspected some 1.5 in diameter carbon steel pins which had been induction hardened. Once they had been painted with an anti-rust paint, this should protect them for life.

The group was taken through the technical offices to view the lake from the North East, through floor to ceiling filtered glass windows. The JCB Academy could also be seen from this view. The JCB Academy is a secondary school, established in 2010, and is an innovative school for learners aged 13-18 with an interest in engineering and/or business. The JCB Academy is based in a carefully adapted and renovated mill, which (appropriately) was built by the famous industrial entrepreneur and engineer, Richard Arkwright, in the late 18th Century.

The group then toured the assembly line for the Backhoes. The main frames for the chassis are welded using a Klaas robotic laser welder. After welding, the frames are shot blasted and then washed to remove particles. They are then taken to a manual spray bake booth. In fact, the only robotics involved in the assembly of the Backhoes, are for the welding. The time between the washing and the painting is about two hours.

The chassis then spends two and a half hours going up the assembly line. First the axles are fitted, and then the engines. Further frames are attached on top of the chassis. The 'work station' is then attached. The 'work station' consists of all the parts not made at JCB. It takes 12 minutes to fit these parts. Optimus bring the nuts and bolts in. We were shown the new dumper line.

The cabs, which are delivered fully assembled, are then fitted. As mentioned before, these are manufactured at by JCB Cab Systems Ltd in Rugeley.

The wheels are put on, and then the hoses are connected and the oil put in. The vehicles are then ready for test.

There is a stage along the assembly line where the 3CXeco and 4CXeco machines are emission tested.

The buckets made by TATA are then fitted. The machines also have to go through a leak test under ultraviolet light.

The group then returned to the VIP visitor centre for coffee, biscuits and Quality Street.

All PEEMS members and guests were in agreement that this was a wonderful excursion and give thanks to the Visitor Team, for an informative, very interesting and memorable visit.

(Acknowledgements to the JCB Visitor Centre for proof reading this article.)

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