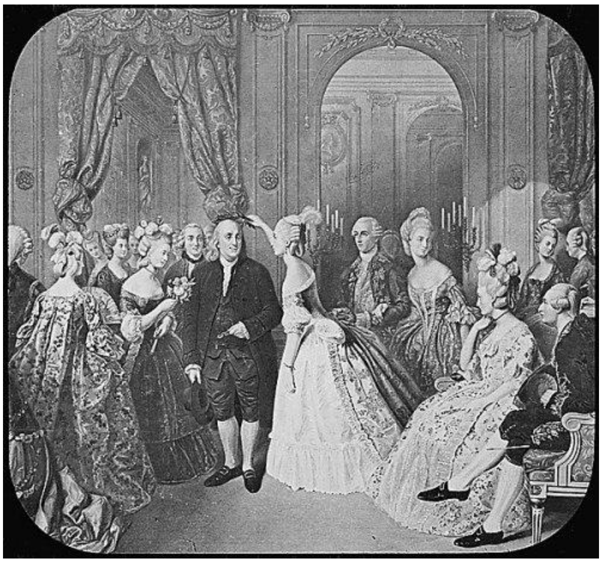

Clock by Dr. Franklin
Il 3 ruote
di
Franklin
di +entusiasta orologiko.it

Il Pendolo a tre ruote di Franklin

Beniamino Franklin inventore e fisico statunitense (1706 – 1790) è universalmente conosciuto come l'inventore del parafulmine, mentre rimangono un po' in ombra sia le sue doti di politico (contribuì in maniera attiva alla Guerra d'Indipendenza firmando un trattato d'alleanza con la Francia), sia le altre invenzioni. Tra queste ogni tanto vengono ricordate le lenti bifocali, oppure il contachilometri o le pinne (anche se queste le aveva già disegnate il solito Leonardo). Oppure, all'inizio dell'estate, quando qualcuno si chiede chi è stato il primo ad avere quest'idea, con sorpresa scopriamo che è stato proprio il nostro Franklin.

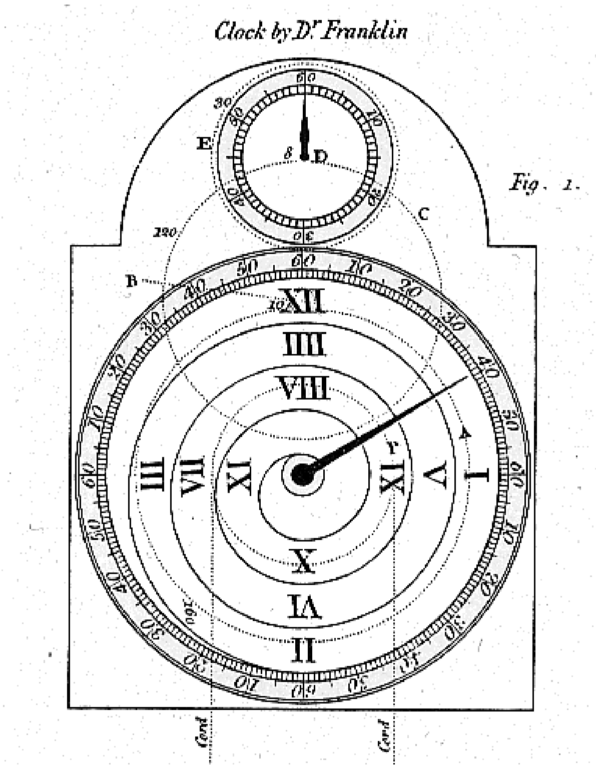
Figura 1 Un antico disegno che rappresenta gli esperimenti elettrici con aquilone e bottiglia di Leida che si può considerare il primo condensatore elettrico.

Beniamino Franklin fu un fisico apprezzato anche in Europa per i suoi studi sull'elettricità, ed ebbe parecchi riconoscimenti da Società scientifiche ed Accademie europee.



Franklin è anche l'inventore di uno dei più strani orologi che si conoscono. La data precisa di quest'invenzione non è nota ma nel 1773 l'astronomo Fergunson ne parla nel suo "Mechanical Exercises" attribuendola proprio a Franklin.

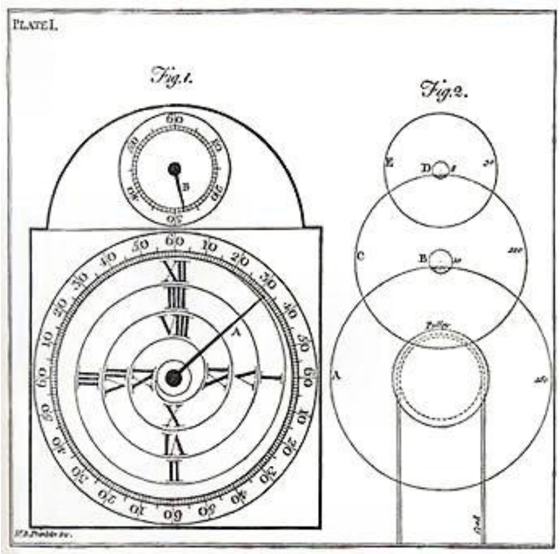
Si tratta di un orologio con tre ruote, due pignoni ed un quadrante a 4 ore. Il quadrante ha una sola lancetta per le ore ed i minuti, innestata nell'albero del bariletto; i secondi sono rappresentati su un quadrante separato. Il quadrante che Fergunson descrive è questo:



Come si deduce dal quadrante la lancetta, nell'arco delle 12 ore, effettua tre rivoluzioni complete (cioè un intero giro ogni 4 ore). Il movimento, a pendolo, era formato da:

- Ruota di scappamento 30 denti
- Pignone 8 alette
- Ruota di centro 120 denti
- Pignone 10 alette
- Ruota principale 160 denti

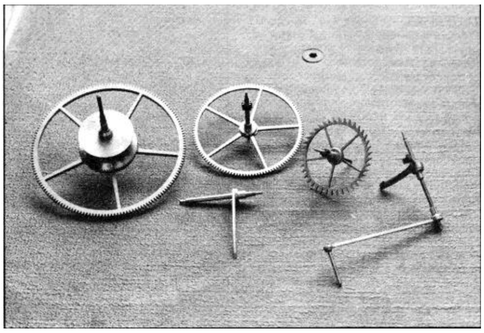
L'energia era fornita da un peso, collegato secondo lo schema del loop di Huygens:



Franklin's Three-Wheel Clock

Il quadrante ha inoltre una suddivisione in 240 parti per i minuti. Certo che non ha una facile leggibilità e forse questo spiega, in parte, lo scarso successo di quest'orologio fabbricato sia come pendolo da pavimento che da muro.

Il perché di quest'orologio và ricercato nelle intenzioni di Franklin di realizzare un orologio economico destinato ai coloni americani. Ricordiamoci che in quell'epoca la pendoleria, sia inglese che francese, non era certo economica, sia per la ricchezza e la qualità dei materiali, ma soprattutto per i vari dispositivi di cui erano dotati gli orologi. Suonerie, sveglie, carillons, ripetizioni anche su più campane erano comuni sia sui *long case* inglesi che sulle *comtoise* francesi.



Ricostruzione del 3 ruote di Franklin. La terza foto dà un'idea della semplicità del movimento.

Il movimento era semplice, ma costruire ruote con un gran numero di denti e la suddivisione del quadrante in 240 parti, comportava un più alto costo di produzione.

L'idea comunque piacque ad orologiai sia tedeschi che inglesi che si lanciarono in un gran numero di varianti. Abbiamo così scappamenti con oscillazioni del pendolo di 1 secondo, il famoso *Royal Pendulum* inglese di lunghezza di circa 1 metro (39,37") :

- Ruota di scappamento 42
- Pignone 6
- Ruota di centro 72
- Pignone 6
- Ruota principale 84

Roentgen e Kinzing usarono invece uno scappamento a caviglie ed I seguenti ruotismi:

- Ruota di scappamento 30
- Pignone 6
- Ruota di centro 96
- Pignone 8
- Ruota principale 120

Altri costruttori ancora utilizzarono il Tre Ruote dotandolo di suoneria, altri lo scheletrarono e ne fecero un orologio da mensola, mentre altri ancora lo hanno dotato di un quadrante 12 ore ed aggiunto anche la lancetta dei minuti.

Quest'ultima realizzazione l'ho trovata sul web (http://www.stirlingsouth.com/richard/clock/three_wheel_skeleton_clock.htm) e la riporto di seguito tradotta per i non anglofili. Personalmente ho qualche dubbio sia sulla buona funzionalità che sulla durata di quest'orologio. I dubbi, ma potrei sbagliarmi, derivano dall'alto numero di denti della ruota principale (480) e dalla potenza della molla di carica (durata 1 mese).

Invece un'altra e più antica realizzazione l'ho trovata nella rivista **Cloks** (7-8-9/ 1982) con un'interessante guida alla costruzione di uno Skeleton clock i cui componenti, all'epoca, venivano venduti in kit. Quest'articolo è riportato integralmente,

Fonti:

Cloks magazine,

J.D.Fowler: http://www.historical-timekeepers.com/fachartikel/three_wheel.html

http://www.pbs.org/benfranklin/l3_inquiring_little.html

http://www.lautard.com/clockpla.htm

Orologio Skeleton a tre ruote

Gli orologi meccanici hanno una serie di ruote (ingranaggi) chiamati treno di ingranaggi. Possono essere azionati sia da un peso che da una molla. Gli orologi che segnano solo il tempo hanno un solo treno di ingranaggi. Orologi con carillon o meccanismi di allarme avranno ingranaggi supplementari guidati da un peso o da una molla dedicati. La maggior parte degli orologi meccanici hanno un treno composto da cinque ruote e pignoni.

Principali componenti di un orologio:

Peso o **Molla -** guida il movimento o la rotazione del treno

Scappamento - controlla il movimento. Ha due parti: una **ruota di scappamento** (la ruota che permette lo scappamento o rotazione del treno) e la paletta (la superficie o la parte di essa attraverso la quale la ruota di scappamento dà impulso al pendolo).

Pendolo - regola il movimento

Questo treno di ruote è dotato di due ruote con 480 denti, due pignoni, uno con 10 denti e l'altro con 8, e di una ruota di scappamento con 60 denti. Ogni ruota ingaggia un pignone.

Ruota principale e ruota di centro

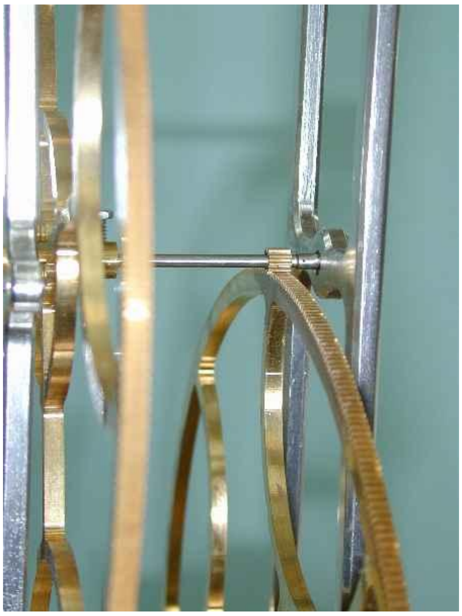
Mentre la grande ruota e la ruota di centro hanno 480 denti, la ruota di centro è leggermente più piccola rispetto alla grande (prima) ruota. Questo per consentire il gioco tra la ruota di centro e l’albero della grande ruota.

Ruota di scappamento e pignoni

La ruota di scappamento è in titanio di .030 " di spessore ed è stata ottenuta con taglio a elettroerosione a filo.

Ruota principale e molla

Il treno di ruote è azionato da una molla di 3 / 4 "x 0,017" x 120 " colllegata alla ruota principale, permettendo all'orologio di funzionare per un mese. La grande ruota fa un giro ogni 48 ore.

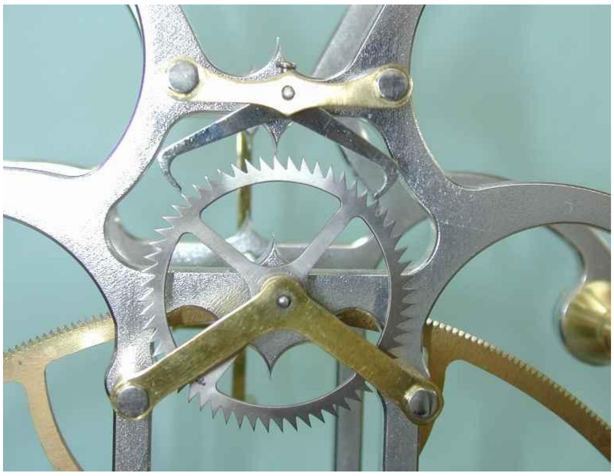


Ruota di centro con pignone

La ruota di centro è pilotata da un pignone con 10 alette sull'albero della ruota di centro. Il pignone con 10 alette ingrana con i 480. denti della grande ruota. Così, la grande ruota compie un giro in 48 ore, e la ruota di centro fa un giro ogni ora. (480 diviso 10 = 48)

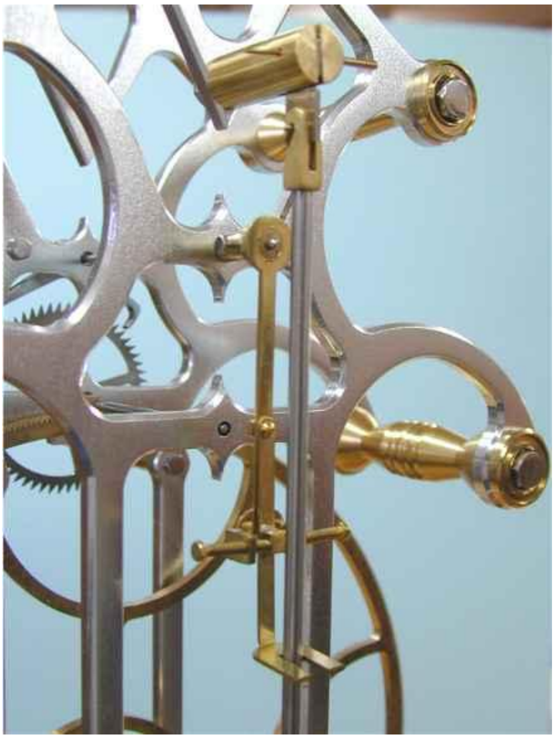
Ruota di scappamento con pignone

La ruota di scappamento è guidata dal pignone con 8 alette posto sull'albero della ruota di scappamento. Il pignone ad 8 alette ingrana con i 480. denti della ruota di centro Così facendo la ruota centro compie un giro per ora, la ruota di scappamento compie un giro al minuto. (480 diviso 8 = 60)



Scappamento ruota e palette

Questo orologio ha uno scappamento dead beat (uno scappamento in cui la ruota di scappamento non indietreggia), progettata per un pendolo. di 9". Le palette oscillano avanti e indietro controllate dal pendolo consentendo alla ruota di scappamento di avanzare di un dente alla volta.



Regolazione dell'oscillazione

Mentre il pendolo controlla l'oscillazione delle palette, la regolazione permette qualche aggiustamento di rotazione in modo che le palette gravino in egual misura sui denti della ruota di scappamento. Questa regolazione è chiamato mettere l'orologio "in battuta".

Il tempo di oscillazione del pendolo (periodo) è regolabile cambiando la lunghezza del pendolo, cioè spostando il peso più vicino o più lontano dal punto di snodo.

Motion Work e lancette

Dal momento che la ruota centro fa un giro ogni ora, la lancetta dei minuti è collegata direttamente all'albero della ruota di centro. Il motion work è costituito da un set di 4 ingranaggi che rallentano la rotazione della lancetta delle ore a 1 / 12 della velocità della lancetta dei minuti. Nella foto sopra, un pignone a 10 denti, attaccato all'asse della ruota di centro muove una ruota a 30 denti. Un pignone ad 8 alette, attaccato alla ruota da 30, trascina la ruota a 32 denti. La lancetta delle ore è collegata alla ruota da 32.

(10 diviso 30 = 1 / 3, 8 diviso per 32 = 1 / 4, 1 / 3 volte 1 / 4 = 1 / 12)

Nella pagina successiva l'articolo di John Lowndes in Cloks Magazine.

The Franklin Three-Wheeler

In the first part of a three-part series, John Lowndes tells how to set about the construction of a Franklin three-wheel clock.

Part 1

WHEN Dr Benjamin Franklin invented a three-wheel clock his objective was to simplify the construction of a reliable time-keeper without loss of any of the normal time-keeping functions. A single hand indicating hours and minutes on the unconventional principal dial eliminates the need for the three wheels and one pinion used in the motion work of a conventional clock. The hand revolves once in four hours and allows further simplification since a shorter time train than normal can be used. This reduces the number of wheels to three for a 30 hour clock.

Traditionally, a Franklin clock has a weight-driven movement with the main hand mounted on the barrel arbor. The pendulum usually beats seconds which are indicated on a separate seconds dial. The only disadvantage of this arrangement is that one must know the time to within four hours instead of twelve when telling the time. This and the initial difficulties in reading the time from the unusual dial tend to be overcome with usage.

The clock to be described in this series of articles is not of the traditional Franklin design. The movement is skeletonised to make an attractive feature timepiece and the dial modified to allow a clearer view of the wheelwork. A pendulum having a ¾-second beat is used which has an overall length of about 2ft. This is much less vulnerable to disturbances than a true royal pendulum when fitted to a wall clock. To accommodate this, the number of escape wheel teeth have been increased to 40. In other respects, the clock has a traditionally Franklin train. The great wheel has 120 teeth, drives a pinion of 10 leaves on the second arbor and a second wheel of 120 teeth drives an escape pinion of eight leaves. This gives the required overall ratio of 240 to one to allow the main hand to revolve once in four hours and the second hand to revolve once per minute.

With such high wheel counts, it follows that the diameters of the wheels must be fairly large. Choosing a wheel pitch of 42 dp (module 0.6) gives a great wheel diameter of just under four inches and allows a principal dial of about 5¼in diameter to be fitted to the clock. Wheels of the sizes given should be within the capacity of most small lathes except Unimats which have only a 46mm centre height. An alternative train count will be given for Unimat owners as the series proceeds.

This clock has a barrel which is like a small capstan winch instead of the spiked pulley normally used for cord driven clocks. This innovation is very effective and may well be original.

Maintaining power is fitted to the barrel to eliminate the need to stop the pendulum when the clock is being wound. This reduces the daily winding operation to lifting the large weight and allowing the small weight to fall by gravity.

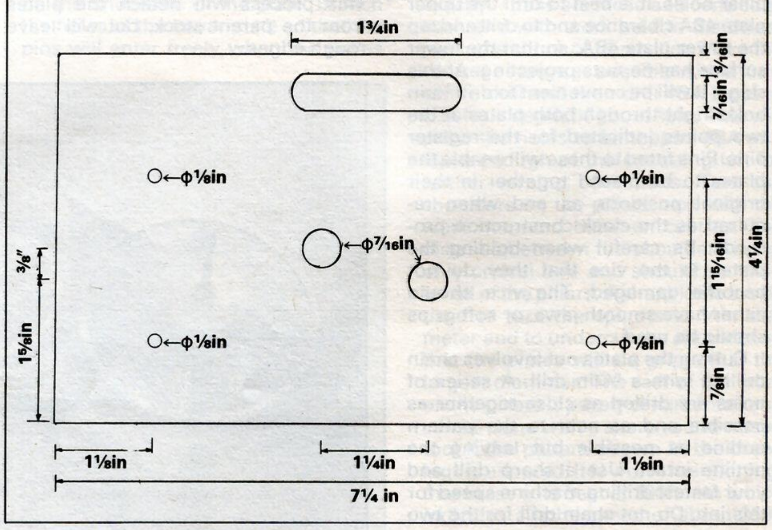
Chronos Designs Ltd, have a cutting list and will supply all the brass parts in the form of a kit. This will include all of the sheet material, wheel blanks and rod required to complete the clock.

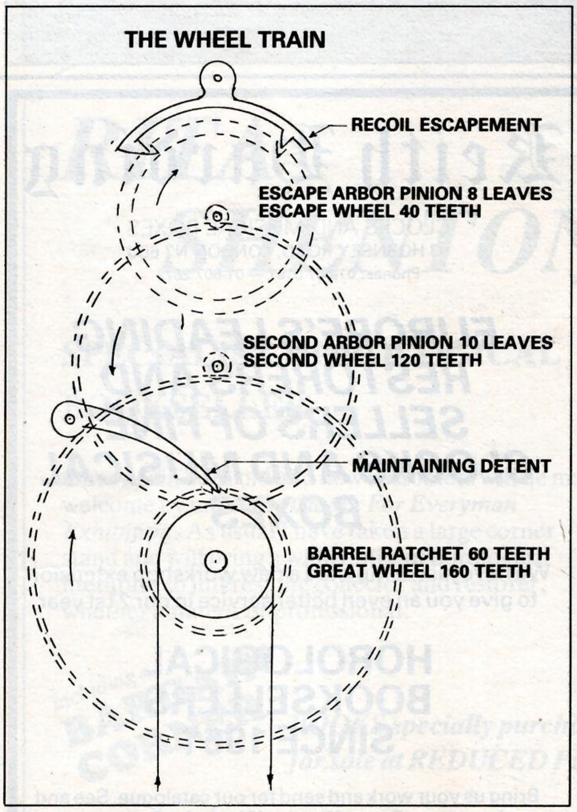
MATERIALS

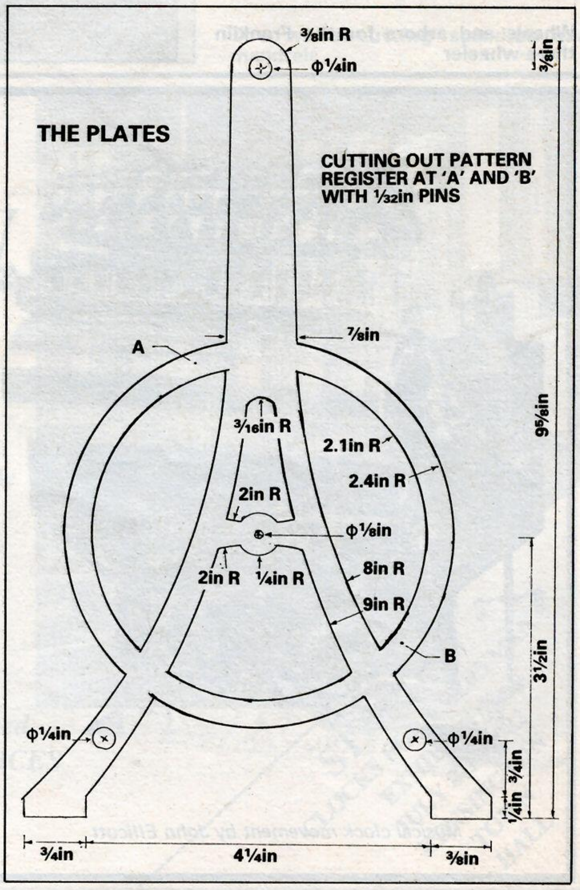
Plates 10in × 6in × 3/16in hard compo brass sheet – two off
Baseplate 7¼in × 4¼in × 3/32in hard compo brass sheet – one off
Great Wheel blank 4in dia × ⅛in hard compo brass
Second wheel blank 3in dia × 5/64in hard compo brass
Escape wheel blank 2in dia × 1/16in hard compo brass
Chapter and Seconds ring 5½in dia × 1/16in hard compo brass
Barrel ⅞in × 1½in dia free cutting brass rod
Pillars and wheel collets 12in × ½in dia free cutting brass rod
Feet and great wheel collet 3in × ⅞in dia free cutting brass rod
Dial pillars, hand collet etc 5in × 5/16in dia free cutting brass rod
Large weight case 4in × 1¼in OD × 20 swg brass tube
Small weight case 3in × ⅞in OD × 20 swg brass tube
Pendulum bob ½in × 2¼in OD × 20 swg brass tube
Pendulum bob 2¼in dia × 3/32in hard compo brass blanks – two off.

Probably the easiest way of cutting

THE BASEPLATE 3/32in BRASS SHEET





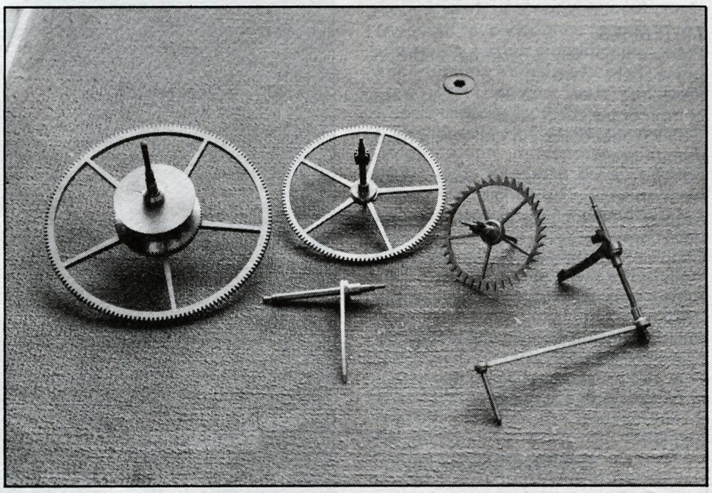


Top: The base plate is made of 3/32in brass sheet. Above: Representation of the wheel train. Right: Half-size cutting pattern for the plates.

the plates out is to glue a paper pattern to one plate and cut the two out together. A copy should be taken from the drawing and cut out so that the outlines remain. This can be stuck to one plate using resin 'W' wood glue. The plates can then be fastened together at the points indicated for the pillar holes. It is best to drill the upper plate 4BA clearance and to drill and tap the tower plate 4BA, so that the lower surface has no nuts projecting. At this stage, it will be convenient to drill 1/32in holes right through both plates at the two points indicated for the register pins. Pins fitted to these will enable the plates to be placed together in their original positions as and when required as the clock construction proceeds. Be careful when holding the plates in the vice that they do not become damaged. The vice should either have smooth jaws, or soft grips should be used.

Cutting the plates out involves chain drilling with a 5/64in drill. A series of holes are drilled as close together as possible and as near to the pattern outline as possible but leaving the outline intact. Use a sharp drill and your fastest drilling machine speed for this job. Do not chain drill for the two openings in the upper parts of the plates, because these are not exactly the same in the two plates. Also it is better to leave these openings until after the train has been planted and set up. After the chain drilling has been completed, the holes are joined using an abrafile held in the hacksaw frame. This process will detach the plates from the parent stock, but will leave rough edges.

The edges of the plates now require filing to the outline of the pattern and given a general clean up. A 10in flat file and a 10in crossing file will be found useful for the bulk of the work. Do check the work as you proceed with a square, to ensure that the filed edges are at right angles to the face of the plates. The plates can be smoothed by draw-filing with a fine file and followed by emery sticks. However, do not be



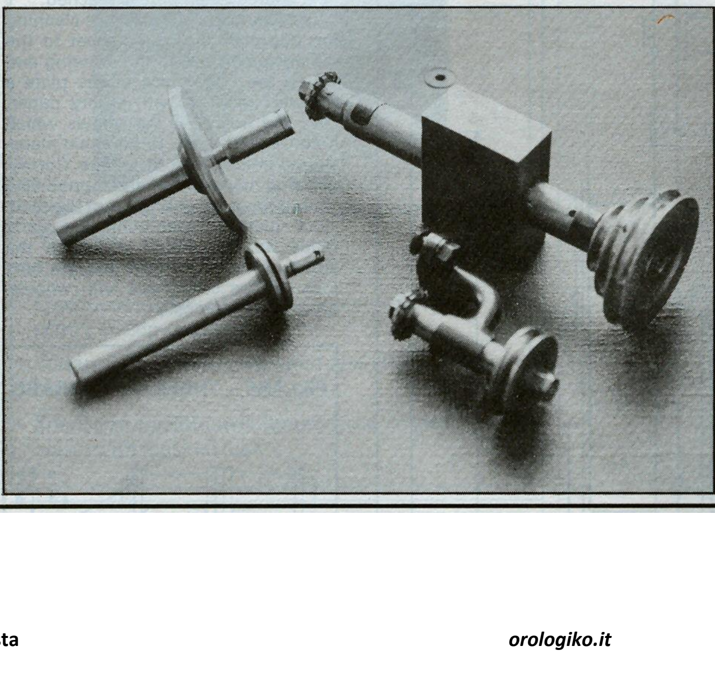
Wheels and arbors for the Franklin three-wheeler

too fussy about finish at this stage, because there is more work to be done on the plates before the clock is completed.

The holes for the pillars now require opening up to 1/4in diameter using a drill followed by a reamer if you have one. To retain the clamping position, remove one 4BA screw at a time, open out the hole and replace with a nut and screw. This way, both plates will be identical. Finally, drill a 1/8in hole at the barrel arbor position.

The plates can now be separated and fitted with register pins. I find bits of sewing needle suitable for this purpose. Broach the register holes so that the pin is a drive fit in the front plate and tap home, leaving 1/8in projecting on the underside of the plate. Broach the holes of the lower plate so that the pins will enter freely when the plates are placed together. These pins will then be available to give a positive location whenever the plates are put together.

For the pillars three lengths of 1/2in diameter free cutting brass rod are required and these should be cut a little over 2in long to allow for facing to 2in exactly. These are faced and centred at each end with work held in the three-jaw lathe chuck of 1/2in collet. Make the centres as large as possible with a 3/16in centre drill and then drill 4BA tapping size for a depth of about 5/8in. This will allow the holes to be tapped 4BA and leave enough of the centreing left for further turning operations. Turn the shoulders on the pillars next with the work mounted between centres. The distance between the shoulders is the only critical one and should be 1 3/4in for all of the pillars. A sharp knife tool is used to turn the spigots to 1/4in diameter and to undercut the shoulder so that the plates will be gripped at the largest diameter. The rest of the work on the pillars is purely ornamental, and can be done with a sharp round-nosed tool if the pattern shown in the drawings is adopted. It is worth mentioning, that brass cuts best at 300ft/min which indicates a lathe speed of about 2500



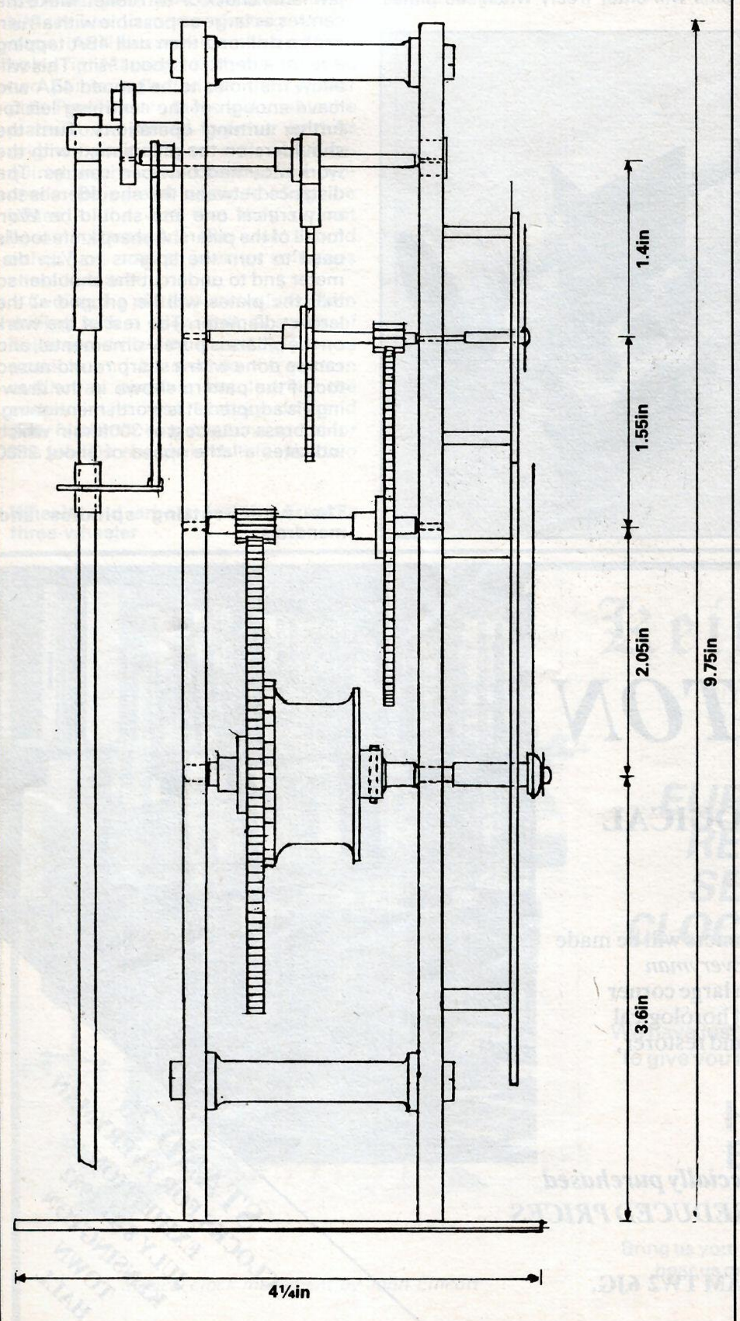
The wheel-cutting spindles and mandrels

rev/min or as near as you can get to that for ½in diameter work.

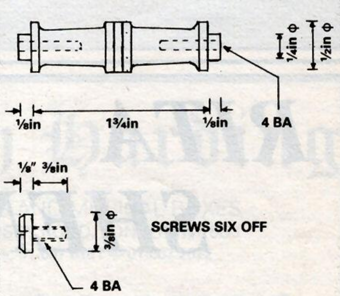
The pillar screws will have to be made specially if they are to look right and it is a good idea to make them from silver steel, which blues well. Making screws is chuck work and requires a speed of about 500 rev/min. Most of the work can be done with a knife tool and the screw heads should be undercut in the same way as the pillar shoulders. The 4BA thread is cut on a 0.14in diameter. The screw head is a fairly straightforward job involving facing with a knife tool and bevelling with a hand graver. Cutting the slot can be done with the hacksaw. The heads of the screws should be polished with emery sticks and blued. The latter job involves heat and may be done with a gas torch, or in the oven if you prefer to do it that way. Watch the oxide colours as they change and remove from the heat source when blue is reached.

The baseplate just involves cleaning the edges of the brass sheet to the dimension shown in the drawing and giving the upper face of the plate a general clean up with emery paper. Only the holes for the screws which hold the base plate to the main plates should be drilled at this stage. Corresponding holes drilled and tapped 6BA should be made in the feet of the main clock plates. Assembling the parts made so far should complete the structural work for now and the next jobs will be concerned with wheels, arbors and pinions.

GENERAL CLOCK LAYOUT WITH APPROXIMATE DIMENSIONS



PILLARS – THREE OFF – BRASS



Above: Elevations of pillars and screws. Left: General clock layout with approximate dimensions.

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NEXT MONTH:

Wheel cutting

John Lowndes continues with the construction of the Franklin three-wheel clock by describing how to cut and cross-out the wheels, how to make the escape wheel using flycutters and how to turn off the barrel plus its ratchet and arbor.

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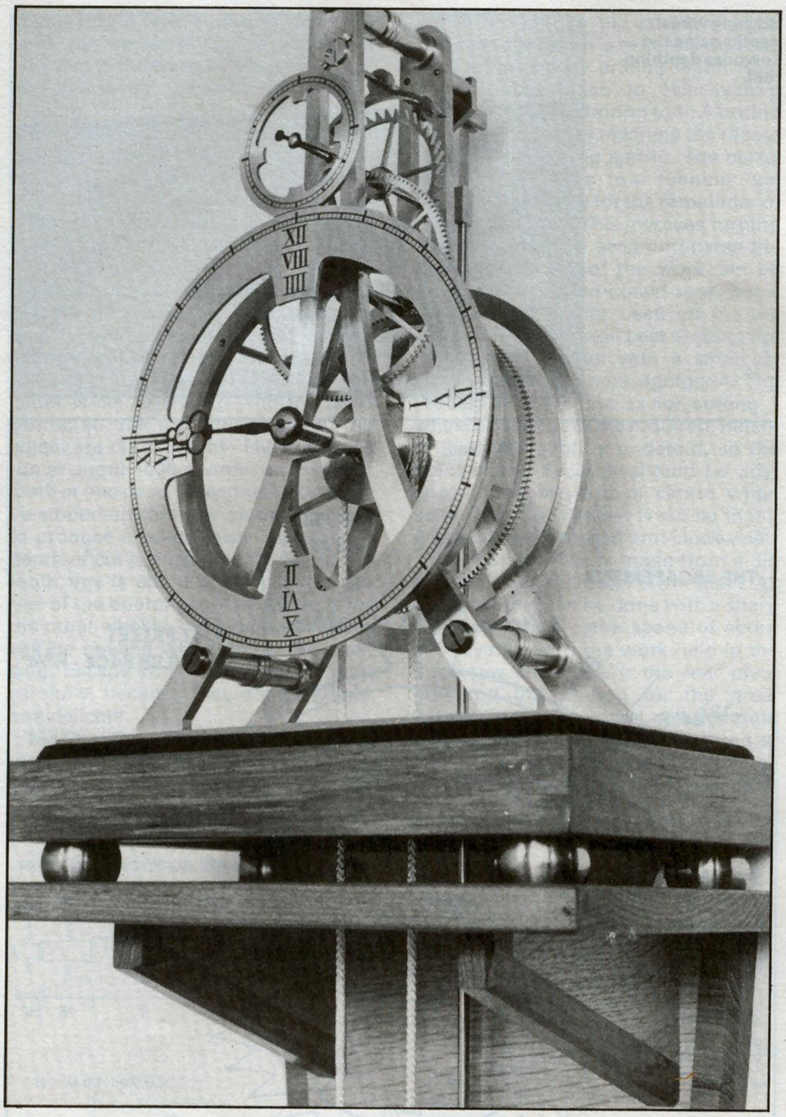


The Franklin Three-Wheeler

Part 2

John Lowndes continues his series on the construction of a Franklin three-wheel timepiece with instructions for cutting of the wheels and arbors.

THE PITCH chosen for the wheels of this clock is 42dp (0.6 module) and the tooth form is the usual epicycloidal used in clockwork. I have assumed that cutters will be available since they can now be hired from cutter banks. A number two cutter will be needed for the wheels and numbers nine and ten for the pinions. Some means of driving the cutters will be required. Cutter spindles for vertical slide mounting and for top slide mounting are available. Either type will do all that you will require. You will also require some means of holding the wheel blanks and it is worth making two flanged mandrells for this purpose. The shanks can either be made to fit the lathe headstock taper, or made to fit a large collet.

A driving attachment will also be necessary for the wheel cutting process. Normally, I use a division plate mounted on the rear of the headstock, but the 160 tooth wheel had me beaten. I solved the problem by using the lathe change wheels. Since readers may be similarly placed I have included sketches of the change wheel combinations with the drawings for the two wheels. If you do use change wheels, mesh them tightly so that there will be no backlash.

To make a wheel, the blank is drilled and reamed ¼in diameter through its centre so that it will fit the flanged mandrell. Turn the blanks to the outside diameters given for the wheels ready for the tooth-cutting operation. Set up the cutter spindle on the lathe and arrange that the cutter is centred with the tailstock centre. This will ensure that the teeth will be radial. A suitable drive is now needed for the spindle and a small electric motor of about 1/10hp mounted on the lathe boring table is a commonly used method. Small lathe owners who will probably not have enough room for this, will find it more convenient to arrange a drive from a motor or electric drill mounted at the back of the lathe. A spindle speed of about 2500 rev/min gives good results when cutting brass wheels. Wheel teeth of this pitch can usually be cut at one pass and should

> Unimat lathe owners will not be able to machine a 160 tooth wheel, so slight modifications to the train will be necessary. If the great wheel blank is carefully shaped by sawing and filing so that it can just be turned its diameter will be very nearly 92mm which is about the correct diameter for a 150 tooth wheel. To keep the overall train ratio the same, it will be necessary to increase the number of teeth on the second wheel to 128. This is an awkward figure, I know, but it can be divided using change wheels. The correct outside diameter for a 128 tooth wheel is 3.05in, so a slightly larger blank than the one given in the materials list will be required.

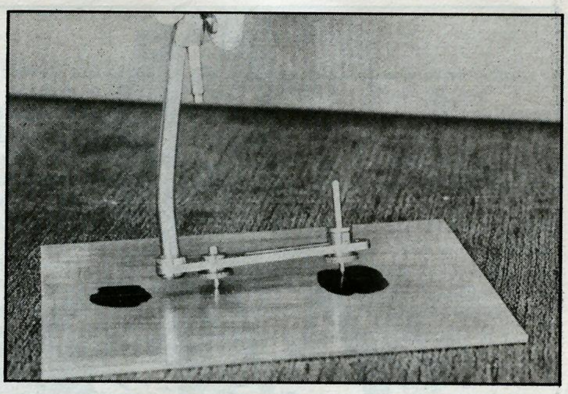
be cut to a depth where there is just a minute flat at the tooth tips. It is a good idea to blacken the wheel rim with a felt pen, and cut two adjacent teeth. The depth of cut is then adjusted until only a very fine line remains. This is the correct depth. Lock all adjustments and cut the remainder of the teeth.

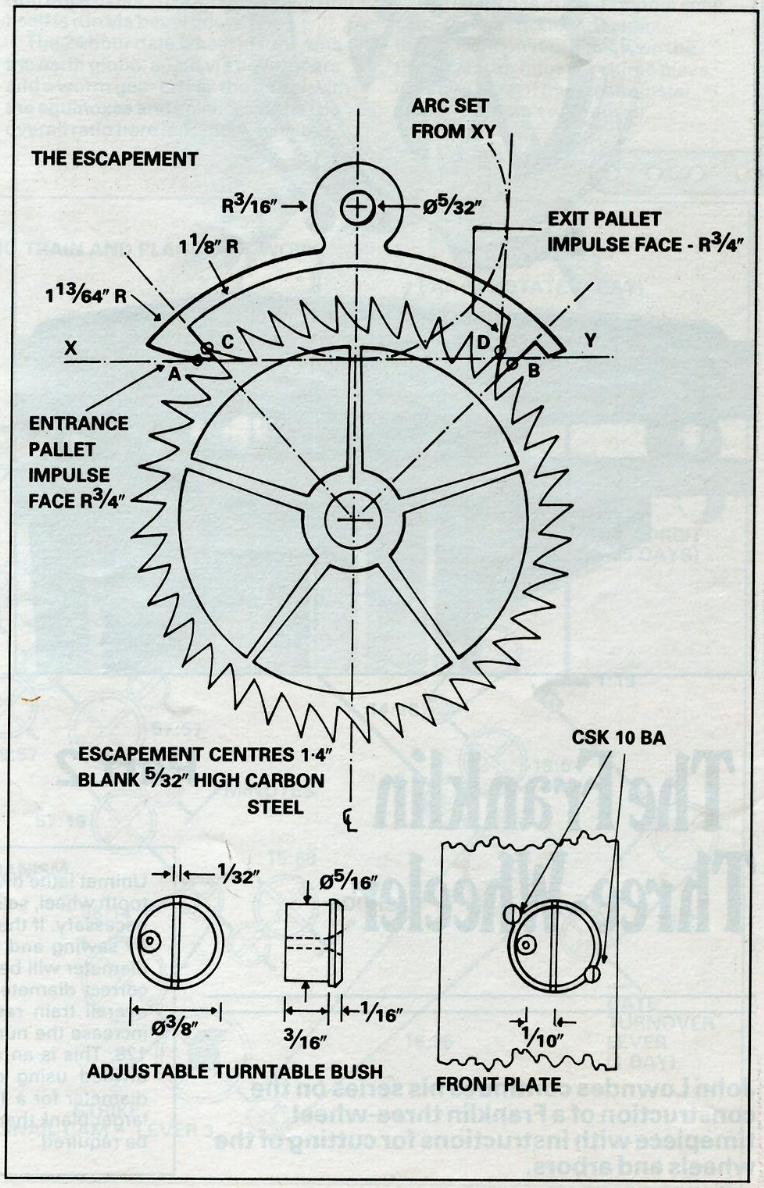
While the lathe is set up for driving wheels, it is a good time to mark out the crossings using a scribing block on the lathe bed. Set the scriber point to lathe centre height for this operation then the spokes will be radial. The circular markings for the rim and centre are marked by rotating the blank with the scriber set to a suitable height. I have shown five crossings in the drawings, which will mean setting whatever dividing method you use to divide by five. Its a good idea to coat the blank with marking out blue, so that scribed marks will show up better. This should be done before the marking operation.

The wheel crossing operation involves cutting out sections of the wheel to leave the spokes. Remove the bulk of the metal using an abra-file held in the hacksaw frame, having first drilled holes to enable the tool to be started. Hold the wheel in the vice for this operation, taking the usual precautions to prevent vice damage. Next, clean up the crossings with second cut files until they are near to their final sizes. Continue the process with finer files, down to six cut if you have them to obtain a smooth finish. Finally, burnish all the openings with a steel knitting needle or similar tool to give a polish to them. It is worth taking time over the above operations, because the final appearance of the clock depends so much on the wheelwork. Points to watch are the corners: they should be square and sharp and the inside of the rim of the wheel should be circular. The work is made easier if crossing files are used for the curved parts. After the crossing operation, the faces of the wheels will require cleaning. Lay a sheet of number 0 emery paper face up on a really flat surface and rub the wheel on this until all marks and scratches have been removed. Repeat with finer grades down to 3/0 to give a polish. Well worn 3/0 gives the best results.

The wheels are completed by making collets for them. Making these involves relatively simple turning operations with a knife tool. Make the spigot for the wheel a good push fit and undercut the shoulder so that the wheel seats well. Drill the centre hole at the same setting, then it will be concentric with the spigot. The rest of the turning is just for looks, and is done with a parting tool which is traversed to form the shank of the collet. To complete, polish with emery sticks and part off. Turn the bevels with a small hand

Scribing wheel depths using the Lowndes depthing tool.





graver taking light cuts with the collet held by its spigot. The wheel is attached to the collet by pressing home and following up with some light riveting. Grip the collet by its shank in the three-jaw chuck and use a small graver on the tee rest to true up the riveting in the lathe to finish the job.

Making an escape wheel is not much different than making any other wheel apart from cutting the tooth form. I use flycutters for this job and have shown a suitable one on the drawings. It is made from silver steel and hardened and tempered to straw colour. An adaptor will be needed to hold this in the cutter spindle. The point of the cutter is set to line up with the lathe centre, so that the radial faces of the wheel are cut correctly. Flycutters are run at about 4000 rev/min and will cut teeth at one pass. They must, however, be stoned up carefully on the oil stone to produce a good finish. The correct depth of cut is such that the flat at the tooth tips is about 0.006in wide. The rest of the operation is the same as for the other wheels, but a little extra care will be needed when doing the crossing. Escape wheels have to be held carefully, because they are very light and delicate.

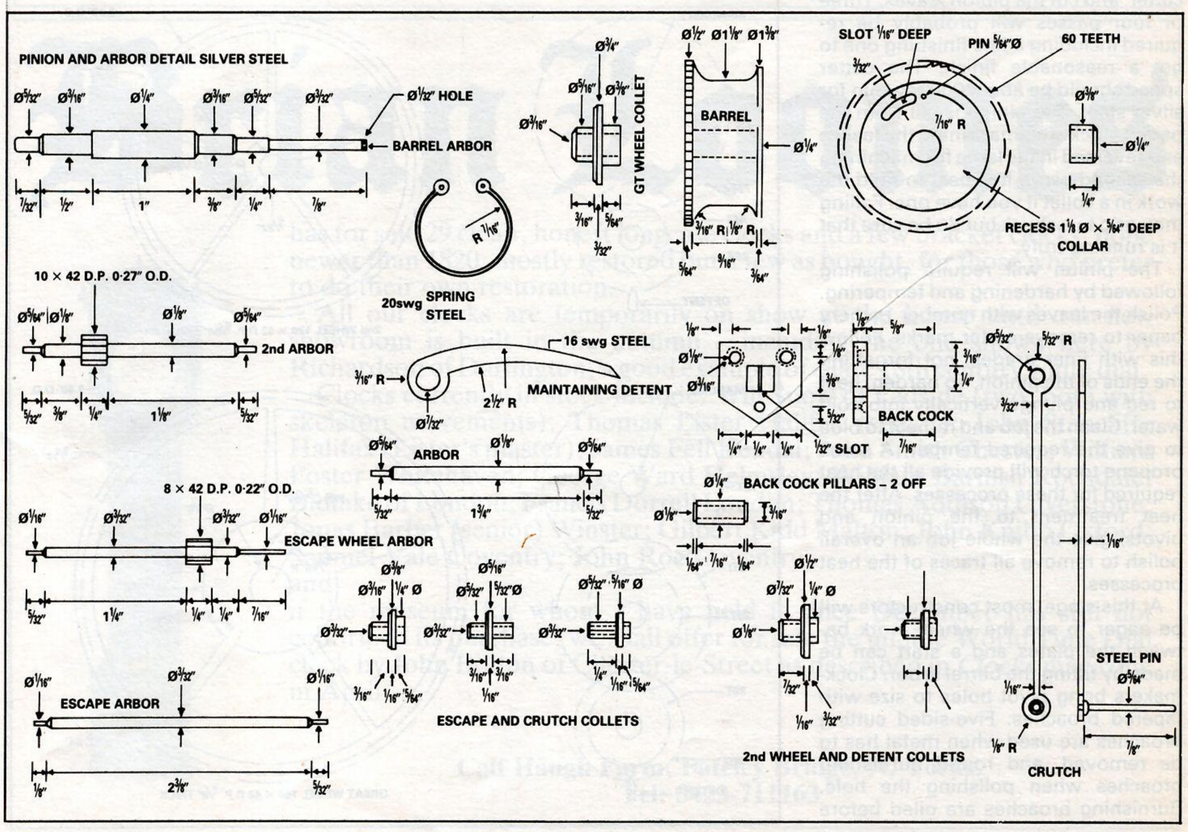
Making the barrel starts off as a three-jaw chuck operation, both ends being faced with a knife tool and the barrel brought to the correct length. The next operation is to centre drill one end, follow up by drilling 15/64in right through and finish to 1/4in with a reamer or a small boring tool. A boring tool is then used to machine the recess for the maintaining spring. The barrel is then held on a true running 1/4in diameter mandrell for the remainder of the turned work. This involves turning the section which accommodates the clock line. Some of the work can be done with a round-nosed tool, but a round-nosed graver used on the tee rest will form the radii best. Cutting the maintaining ratchet with a small fly cutter will be the next operation. The process is the same as for cutting a wheel and 60 teeth are required. Ratchet teeth are slightly undercut, so the point of the flycutter should be advanced 1/16in forward of centre when setting up. The ratchet is cut so that it will hold when turned anti-clockwise.

The barrel arbor is made from a 3in length of 1/4in diameter silver steel. All of the turning can be done with a sharp knife tool and a lathe speed of about 800 rev/min with the work held in the three jaw chuck. Turn the rear pivot first and the seating for the great wheel. The great wheel collet should be a tight push fit if you are going to rely on the fit to hold the wheel. Alternatively, you can make a sliding fit and secure the wheel with loctite when you assemble the components.

The pivot will need polishing with a well-oiled pivot file followed by a burnisher or emery stick to remove all traces of the turning operation. Reverse the work in the chuck and proceed with front end. This is similar to the last operation, but has a few more stages. Take care that the distance between the pivot shoulders is such that they will fit between the plates with only a small amount of end play, say 0.005in. When you have got this correct, give the pivot and its shoulder a good polishing as before. The whole arbor should now receive a general cleaning up and the pivot file may be useful here. Finally, check that the barrel rotates freely on the centre section of the arbor and make corrections if necessary.

A collar will be required to hold the barrel in its correct position on the arbor. This can be made to be a tight push fit, or can be secured with a small grub screw. Leave the final assembly of the barrel until the wheel train has been depthed.

The maintaining spring is made from 20 swg piano wire and bent to shape with round nosed pliers. This fits over the 5/64in diameter studs fitted into the barrel recess and the great wheel. The studs are threaded 8 BA and screwed



home tightly into their respective components. It will be noticed that the barrel recess has a slot which restricts the movement of the great wheel stud. This can be made by chain drilling three 3/32in diameter holes and joining them with a miniature cold chisel. The maintaining detent is a straightforward filing job, it is made from 1/16in mild steel. The detent is colleted in the same way as a wheel and fitted to a 1/8in diameter silver steel arbor. The pivots are turned and polished in the normal way, and the distance between the shoulders should be such that there is a minimum amount of end play. The pivots should be hardened and tempered to blue colour.

The pinions are integral with the arbors in this clock and are made from silver steel. The first stage is a turning job done with the work held in the three-jaw chuck. One pivot can be made and polished to begin with and the longer part of the arbor machined to diameter. Check the job here, the collet of the wheel fitted to that arbor must be a good fit when the arbor is finished. Actual dimensions are not critical. The second stage is to withdraw a bit more of the silver steel from the chuck and machine the next section to the outside diameter of the pinion.

Set up the lathe for wheel cutting, taking extra care when centring the cutter, and cut the pinion leaves. Three or four passes will probably be required including a fine finishing one to get a reasonable finish. The cutter speed should be about 200 rev/min for silver steel. The pinion is cut from the parent stock after machining the leaves and reversed in the lathe for machining the second pivot. It is best to hold the work in a collet if you have one. Failing that, grip in a chuck but do be sure that it is running truly.

The pinion will require polishing followed by hardening and tempering. Polish the leaves with number 1 emery paper to remove cutter marks. Follow this with finer grades, not forgetting the ends of the pinion. To harden, heat to red and plunge vertically into cold water. Clean the job and re-heat to blue to give the required temper. A small propane torch will provide all the heat required for these processes. After the heat treatment to the pinion and pivots, give the whole job an overall polish to remove all traces of the heat processes.

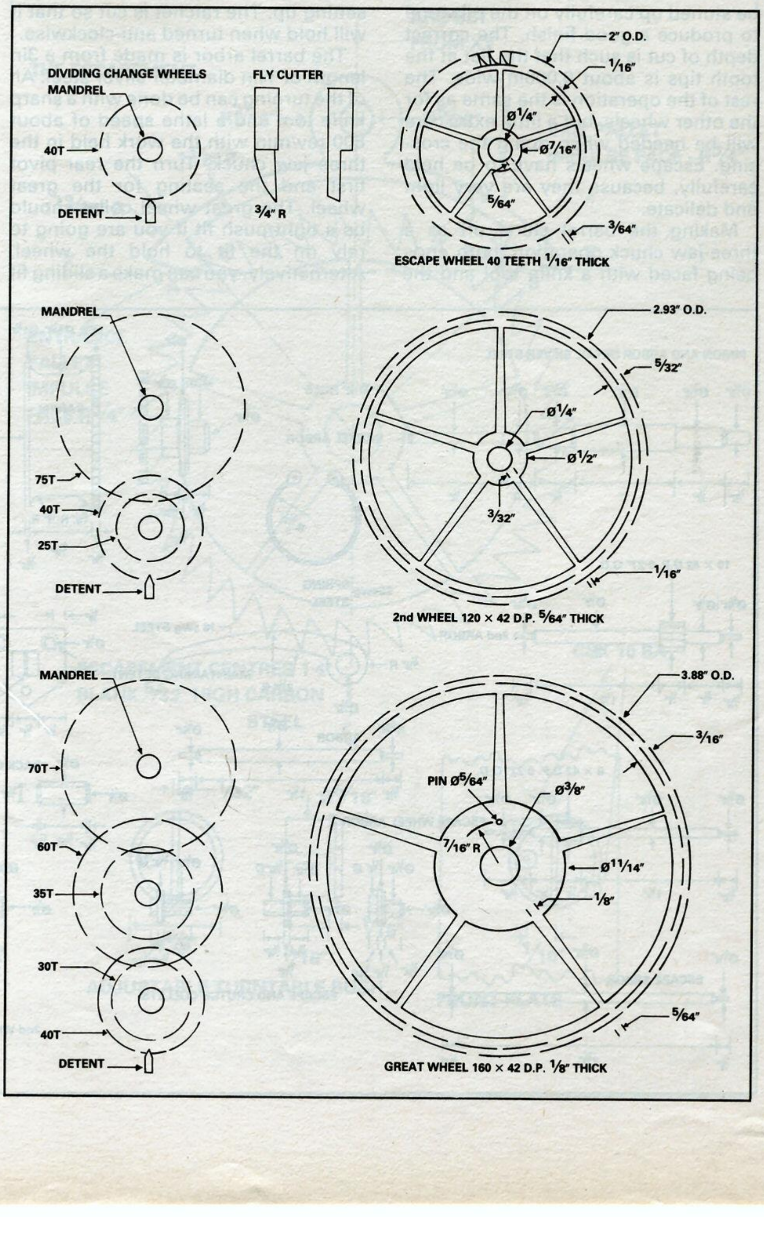
At this stage, most constructors will be eager to see the wheel work between the plates and a start can be made by fitting the barrel arbor. Clockmakers bring pivot holes to size with tapered broaches. Five-sided cutting broaches are used when metal has to be removed, and round burnishing broaches when polishing the hole. Burnishing broaches are oiled before they are used and in addition to polishing, the hole is work hardened. Clock pivot holes are not parallel sided, they taper towards the middle after broaching. Fits are slacker than those normally used in engineering and all the arbors should easily fall under their own weights when the movement is tilted on its side.

The second wheel arbor is fitted next, but since the great wheel and second arbor pinion have to mesh correctly a depthing tool will be required. I use a slotted depthing tool with runners to hold the arbors between female centres. A second runner carries the wheel and the two can be brought together to obtain the correct meshing centres. Hardened points on the runners enable this dimension to be transferred to the plates.

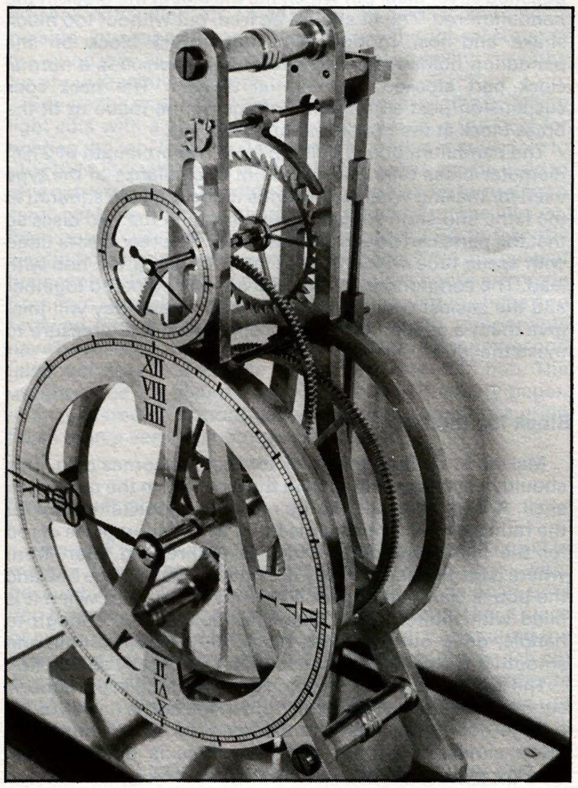
The pivot hole is drilled at the centres indicated with both plates placed together and registered. After broaching to size oil sinks are formed with a countersink. The oil sinks should be made fairly deeply in the plates to reduce the length of the pivot hole in the thick plates we are using.

With the depthing completed, the barrel arbor components can be assembled for keeps and the second wheel fitted to its arbor.

These can now be fitted between the plates and tested for free running, and the maintaining detent can be set to its correct position. The detent pivot holes are made in the same way as those for the upper wheels. If all is correct so far, repeat the depthing process for the escape arbor but do not fit the wheel until the escapement has been made.



John Lowndes winds up his series on the construction of the unique three-wheel clock designed by Dr Benjamin Franklin.



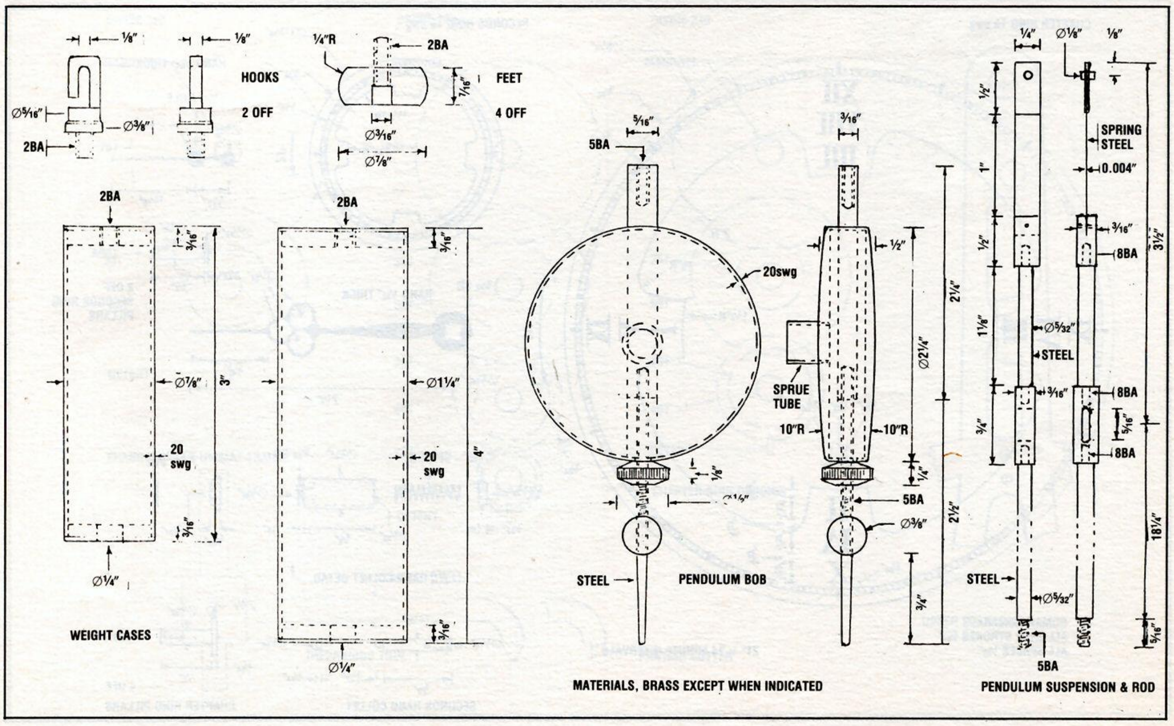
The Franklin Three-Wheeler

Part 3

CLOCK pallets have to be hardened, and are normally made from a high-carbon steel. A piece of gauge plate or an old file suitably prepared are ideal materials. If an old file is used it will need annealing by heating to red and allowing to cool very slowly. Some preliminary work will also be necessary to remove the teeth to make a usable blank. When the blank has been prepared, I usually heat it until it turns blue then scribed marks will show up well.

Marking out can best be carried out in a slotted depthing tool and drilling a hole in the blank where the escapement arbor is fitted is an aid to the marking process as well as proving a convenient way of securing the blank. Fit a runner for the escape wheel 1.4in away from the arbor centre for the escape wheel. This is the correct centre for a 2in diameter escape wheel where the pallet span is 90° or in this case 9½ tooth spaces.

Place the escape wheel on the runner and mark with dots positions A, B, C, and D (see drawing in last month's issue). Dots A and B are five tooth spaces from the centre line and dots C and D 4½ spaces from the centre line. Scribe lines passing through the escape wheel centre and dots C and B on the blank. Scribe a line passing through dot A and passing between dots D and B and with dividers. Mark in the semicircle centred at the pallet arbor centre and touching the last scribed line. Draw a tangent to this curve passing



through dot C and you will now have the positions of both pallets and their outlines correct. The remainder of the marking for the general outline of the anchor can be done with dividers.

Shape the blank by sawing and filing to the lines and try it with the escape wheel in the depthing tool. The escapement should be far too tight to operate. Carefully file the impulse faces until the escapement is just at the point of allowing the escape wheel teeth to pass. This is a trial and error job and the escapement should be checked frequently. It is usual to file a curvature on the impulse faces as shown in the drawing. The final stage is a polishing process which should produce enough freedom to allow the escapement to operate and give a very smooth finish to the pallets. The pallets are hardened afterwards by heating to red and quenching in water. They are left in the dead hard state. The anchor is cleaned up and fitted with a collet to suit a 3⁄32in arbor.

Next, the centres for the escapement are transferred from the depthing tool to the plates. The front pivot of the pallet arbor is carried in a turntable bush so that escapement depth can be adjusted. This bush is held by the heads of two 10 BA screws and fits a 5⁄16in diameter hole offset 0.1in from the centre. The hole for the turntable should be reamed if possible and the bush turned to fit the hole. The back pivot is carried by the back cock which also carries the pendulum suspension post. Making the turntable and the cook should be fairly straightforward jobs. Locate the cock by drilling a hole in the back plate of the clock 3⁄32in diameter at the arbor centre, then the arbor can be used to register the cock and the plate while the pillar holes are marked. The pillars for the cock are turned from 1⁄4in diameter brass rod as shown in the drawing. They have registering spigots which fit into counterbored holes in the plates. The cock is secured with 6 BA screws. After the location of back cock has been completed the 3⁄32in diameter plate hole should be opened up to 5⁄16in diemater so that it does not foul the crutch collet.

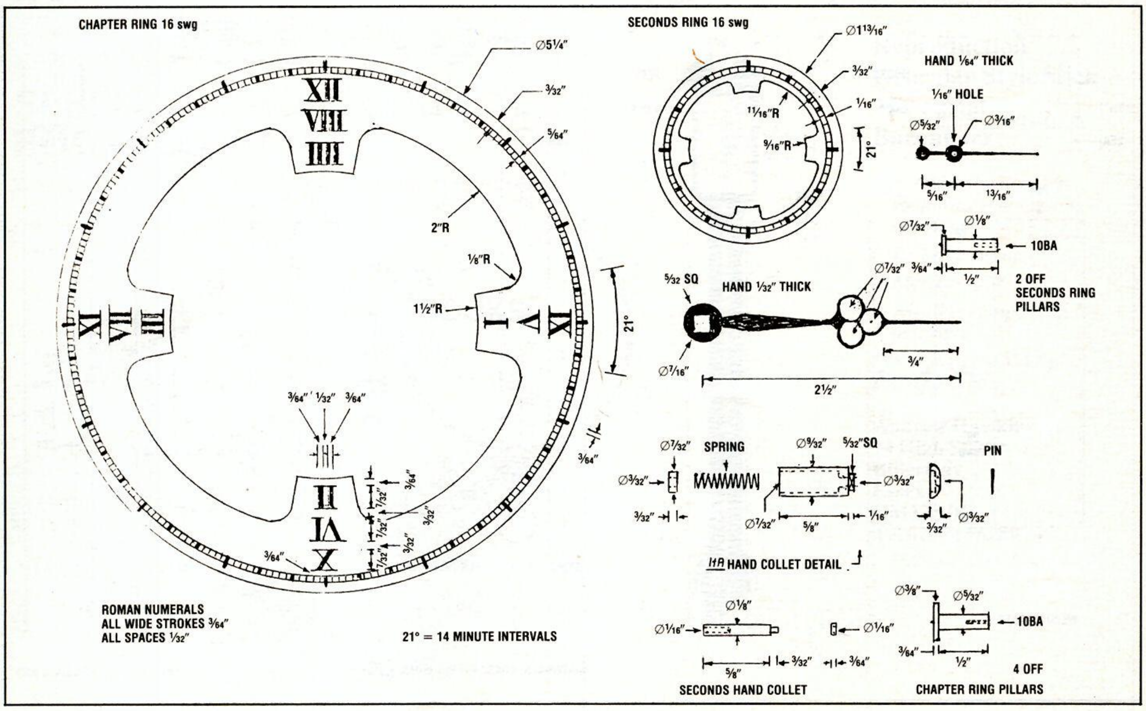
The pendulum crutch is formed from 1⁄16in brass sheet by sawing and filing. One end is fitted with a collet to suit the pallet arbor and the collet is slit with a slitting saw or other suitable tool so that it is a friction fit. This makes it easier to set the clock in beat. The other end is fitted with a turned and polished silver steel pin which fits the slot in the block in the pendulum rod. The fit should be free, but without too much shake and lost motion. The uppermost block on the pendulum holds the suspension spring, which is a normal clock part stocked by material dealers. The back cock suspension post slot should, of course, be made to fit the brass block at the upper end of the spring.

The pendulum bob is built up from a short length of 2¼in diameter brass tube and two 3⁄32in thick blanks of the type used for making wheels. The ends of the tube are squared in the lathe and short registers are turned on the two discs so that the parts can be assembled easily. The rear disc is fitted with sprue tube which is used later for filling the bob with lead. The components of the bob are soft soldered together and the easiest way is to tin the parts where they will join, give them a coating of flux and apply heat and pressure to make the joints.

Block for the bob

Making and fitting the block for the bob comes next. This should be an easy sliding fit in the slot filed in the pendulum shell. A 5⁄32in hole will also be required opposite the slot for the rating thread. The block is fitted with a short piece of rod for the filling operation which is unthreaded apart from where it fits the block. These are fitted in place in the bob and the bob is clamped so that it will not come apart when it is filled with molten lead. When the bob is cool enough to handle, drive out the brass block, file it down a little and smooth it with emery paper so that it is an easy sliding fit.

The bob still requires finishing and polishing in the lathe. A curvature on the back and the front of the bob is turned using a large hand graver on the tee-rest. The centre portion is given similar treatment and the whole is polished with emergy papers. After a suitable finish has been obtained



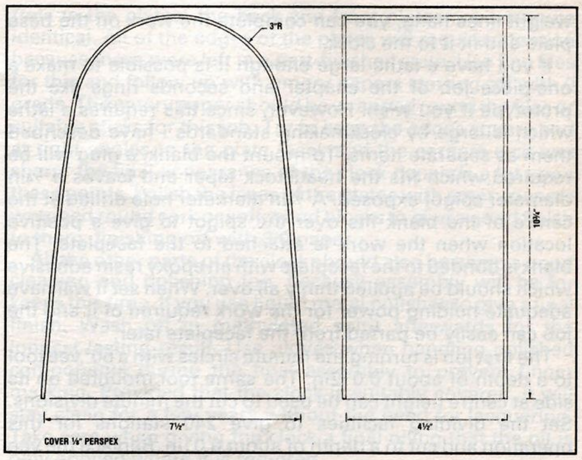
follow up with metal polish and then give the bob a coating of clear lacquer. Cut the sprue tube off to finish the job. The pendulum bob will now require a rating thread and rating nut. Both are fairly simple to make, but knurling the nut may present difficulties for small lathe owners. If knurling is outside your capacity, mill the surface with a wheel cutter in the same way as you would cut a wheel, indexing the lathe for about seventy divisions.

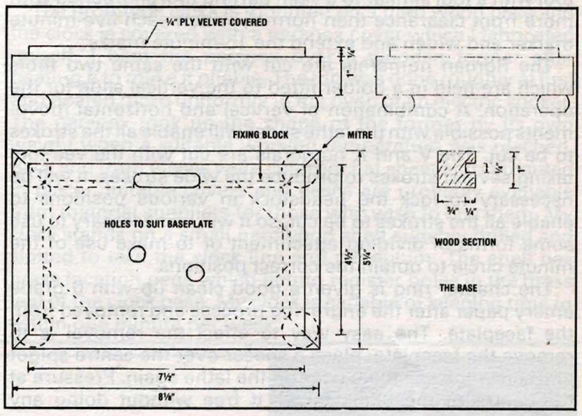
Square the ends of the weight case tubes in lathe by taking light cuts with a knife tool. A four-jaw chuck is the best for holding the job. If a three-jaw chuck is used, it is advisable to plug the tube with wood so that the tail centre can be used to give extra support. The ends of the cases can be turned from scrap cut from the clock plates and should be turned all over. Each upper case end is drilled and tapped 2 BA to take the weight hooks and the lower ones are drilled 5/16in diameter at their centres for the lead filling. Two weight hooks are made from 3/8in diameter brass rod, turned and filed to shape and screwed into the case ends. When all of the components have been made, the weight cases are soldered together and filled with lead in the same way as the pendulum bob. The weight cases are cleaned up afterwards with emery paper, and lacquered. It is more usual to give the weights a grain finish than a very high polish.

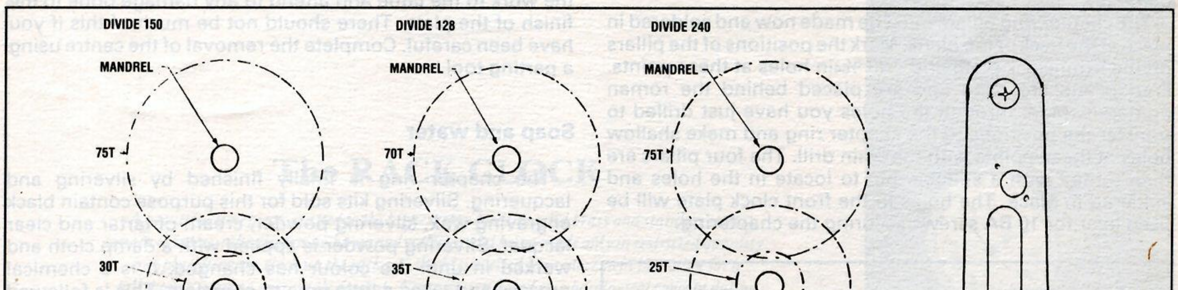
See how it goes

The clock will now be at a stage when the train can be set in motion. Leave the base-plate off the clock to begin with, because you will not know where to drill the line holes until you have seen where the line runs on the barrel. Use a piece of nylon picture cord for a line, wind 2½ full turns round the barrel and hang the weights. Oil all the pivots, the crutch pin and the pallets and see how it goes. After some adjustments have been made to escapement depth and beat it should run successfully. The escapement will have a good recoil if it is set correctly.

When you have observed where the pendulum and the







weight lines hang, you can complete the work on the base plate and fit it to the clock.

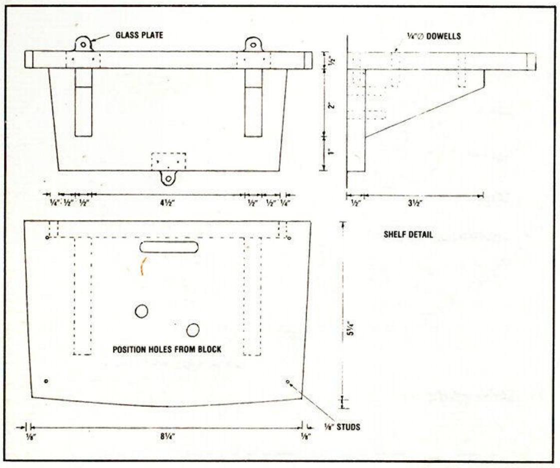
If you have a lathe large enough it is possible to make a one-piece job of the chapter and seconds rings like the prototype if you wish. However, since this requires a lathe which is large by clockmaking standards I have described them as separate items. To mount the blank, a plug will be required which fits the headstock taper and leaves a ¼in diameter spigot exposed. A ¼in diameter hole drilled at the centre of the blank fits over the spigot to give a positive location when the work is attached to the faceplate. The blank is bonded to the faceplate with an epoxy resin adhesive which should be applied thinly all over. When set it will have adequate holding power for the work required of it and the job can easily be parted from the faceplate later.

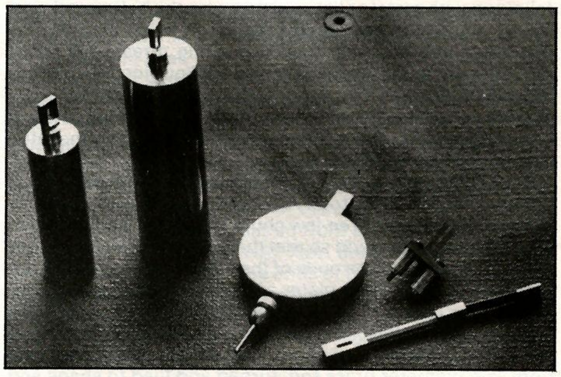
The first job is turning the minute circles with a 60° vee tool to a depth of about 0.012in. The same tool mounted on its side at centre height can be used to cut the minute divisions. Set the dividing facilities to give 240 stations for this operation and cut to a depth of about 0.01in. Replace the vee tool with a tool similar to a 3/64in parting tool sharpened with more front clearance than normal, widen each five-minute marker and widen and extend the 15-minute marks.

The Roman numerals are cut with the same two tools which are held in a holder fitted to the vertical slide for the operation. A combination of vertical and horizontal movements possible with the lathe slides will enable all the strokes to be cut. The V and X numerals are cut with the vee tool taking several strokes to produce the wide strokes. It will be necessary to lock the headstock in various positions to enable all the strokes to be cut, so it will be necessary to use some forms of dividing attachment or to make use of the minute circle to obtain the correct positions.

The chapter ring is given a good clean up with 0 grade emery paper after the engraving process and removed from the faceplate. The easy way to effect the removal is to remove the faceplate, place a spacer over the centre spigot and screw the faceplate back on the lathe again. Pressure at the centre of the blank forces it free without doing any damage.

The chapter ring pillars must be made now and soldered in place at the back of the blank. Mark the positions of the pillars on the front clock plate and drill 5/64in holes at these points. Four pillars are used and are placed behind the roman numerals. Mark through the holes you have just drilled to transfer the positions to the chapter ring and make shallow holes at these points with the 5/64in drill. The four pillars are then turned with a suitable pip to locate in the holes and soldered in place. The holes in the front clock plate will be used later for 10 BA screws securing the chaptering.





The weight cases and pendulum bob for the Franklin three-wheel timepiece.

The chapter ring engraving can now be filled with black wax. Apply heat gently, and melt the wax in the graduations from the stick and finally scrape off any surplus with a piece of card. Follow up with fine wet-and-dry paper, use wet to remove any wax sticking to the wrong places and give the filling a good washing with soap and water. You should now have a nice even black filling in all the graduations.

Return the chapter ring to the lathe, but this time hold it in the large mandrel used for cutting the big wheels. Turn the outside edge to bring it to its correct diameter and attend to the face of the dial. This should be given a grain finish with 0 grade emery paper. Carefully mark out the centre cutaway portion with the scribing block ready for cutting and remove the mandrel with the chapter ring still in place. Hold the job in the vice by the flanged plates of the mandrel and cut and file the inside of the chapter ring to the marks. This process is similar to crossing a wheel and should leave the job attached to the centre at four points adjacent to the numerals. Return the work to the lathe and attend to any damage done to the finish of the plate. There should not be much of this if you have been careful. Complete the removal of the centre using a parting tool.

Soap and water

The chapter ring is finally finished by silvering and lacquering. Silvering kits sold for this purpose contain black engraving wax, silvering powder, cream of tartar and clear lacquer. Silvering powder is applied with a damp cloth and worked in until the colour has changed. It is a chemical process and takes a little time to complete. This is followed up with the cream of tartar applied in the same way which whitens the ring. The ring is given a good wash with soap and water afterwards and when dry is lacquered to prevent tarnishing. The chapter ring is secured to the front with four 10 BA screws when it is fitted to the clock.

The processes used to produce the seconds ring are exactly the same as those for the principal dial. Small jobs like this can be held by a centre nut to a wheel-cutting mandrel for the engraving work. There should be enough usable material cut from the chapter ring for this job.

Some constructors may find that turning a chapter ring is beyond the capacity of their lathes and will be looking for other methods. A trepanning tool as shown in the drawing can easily be made in the home workshop and should have two cutters. The vee cutter is used for the minute circles and the other cutter for finishing the outside of the blank. Both cutters should be made from ¼in diameter silver steel and be hardened and tempered to straw colour. The tool is centred in a ¼in diameter hole drilled through the centre of the blank.

It is best to use the tool in a carpenter's brace.

Dividing the minute circle can be done with a protractor, each five minute interval spans 7½°. Drill right through the blank at these points with a $\frac{3}{64}$in drill and cut the mark out with a piercing saw. The individual minute divisions present a difficult problem since any lack of uniformity will show. Probably, the best solution is to omit them, I only included them on the prototype to keep with Franklin tradition. If you do decide to include them, mark them carefully with a scriber and then deepen the marks with a diamond section graver. Don't attempt the real thing until you have practised on pieces of scrap brass. It isn't easy.

The Roman numerals can probably be cut best in the lathe. This will mean setting up the blank at each of the four stations in turn. A good method is to secure the ring to a plywood disc mounted on the faceplate or held in a chuck. Try to cut all the narrow strokes at least by this method. If it is not possible to do the wide strokes, cut them out with the piercing saw and finish with needle files. Many clockmakers use this method and stick PVC adhesive tape over the holes at the back of the chapter ring to prevent the wax running through. With care, a very neat job can be made.

The hands are cut out by sawing, filing and drilling processes and finished by polishing and blueing. Spring steel is the best material to use, but it is harder material to work. Try to make the hands light and delicate with fine fretwork. Heavy-looking hands spoil the appearance of a skeleton clock. Both the main and second hands require collets which are small brass turning jobs as shown in the drawings. The principal hand collet contains a small compression spring as part of the friction drive and the whole assembly is secured by a taper pin passing through a hole at the end of the arbor. The seconds hand collet pipe is a push-fit on the escape wheel arbor.

The plates still require some work to be done to them to complete the fretting. Work to the job when cutting the upper frets in the plates; the back and front plates are not quite identical. All of the edges of the plates will require attention because these were left in a part-finished state. Use fine files for this and follow up with emery papers starting off with 0 grade. The emery paper should be wrapped round the files or suitable sticks for this job. Try to keep the edges square and at right angles to the plate faces and the corners nice and sharp; the final appearance of the clock depends a lot upon these points. Polish the faces of the plates with emery papers wrapped round cork or soft wood blocks to give a good finish to them, finishing off with 3/0 paper.

All the other parts of the clock should also be given a good cleaning and polishing too, because assembly will be for keeps this time. If you use liquid metal polishes to give a final finish. Wash off in methylated spirit afterwards for the longest lasting result. Use gloves when handling polished components during the final assembly to prevent finger marking. Provided that the clock is suitably covered, it will stay clean for a few years without the need for lacquering. Take care when giving the clock a final oiling that the oil is only applied where it is required.

The prototype clock is mounted on a hard wood base and the clock is covered with a perspex cover which I fabricated myself. I bent the perspex over a wooden former after heating it to make it pliable. The job was done roughly at first and heated more uniformly in the oven of an electric cooker. The perspex took up the shape of the former by its own weight when a suitable working temperature was reached. Back and front pieces were cut from flat sheet and cemented in place. Suitable covers and bases are probably available from material suppliers for those who wish to buy them. My clock stands on a small hardwood shelf suitably drilled and slotted to take the clock line and pendulum. The shelf has brass locating pegs which fit into register holes in the brass feet of the clock base. My clock is capable of keeping time to within one minute per week.

Ho voluto riportare quest'articolo per due diversi motivi.

Il primo è sicuramente la gradevole realizzazione che, anche se in parte rispetta l'idea originale sia di Franklin che dei primi orologiai realizzatori, è caratterizzata da essenzialità e pulizia del *design*.

Il secondo è di poter offrire agli orologiai professionisti ed ai dilettanti, di poter, per soddisfazione personale, costruire interamente un orologio, appagando quello che, sono sicuro, è il sogno di ogni appassionato di orologeria.

Per chi volesse realizzarlo reperendo già il materiale necessario, ho trovato questo fornitore inglese : http://www.clockmaking-brass.co.uk/Benjamin%20Franklin%2030hr.htm che può essere utile anche per la fornitura di singoli elementi.

Infine spero che questa mia raccolta d'informazioni sul 3 Ruote di Franklin, possa essere stata utile se non altro per cultura personale.
