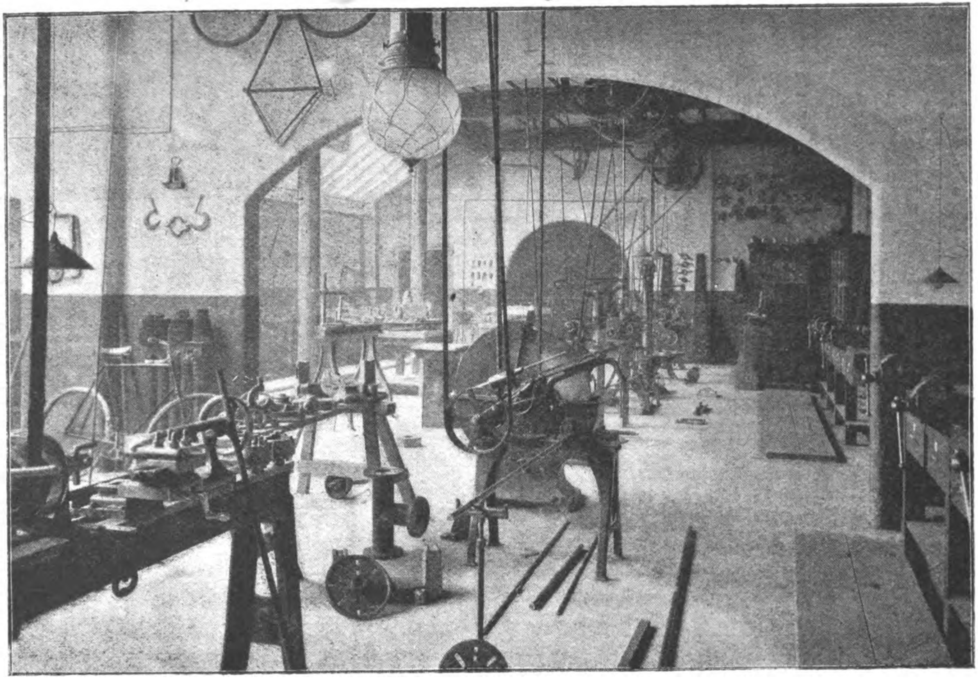

PART OF WORKSHOPS OF NORTHERN POLYTECHNIC INSTITUTE, HOLLOWAY, LONDON, N.

THE MODERN

SAFETY BICYCLE

BY

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WITH 104 ILLUSTRATIONS
AND FIVE WORKING DRAWINGS

WHITTAKER & CO.

2 WHITE HART STREET, PATERNOSTER SQUARE, LONDON

NEW YORK: 66, FIFTH AVENUE

1899

Richard Clay & Sons, Limited,
London & Bungay.

PREFACE

In preparing the following pages I have worked on the supposition that the ordinary safety bicycle is worth a small book to itself. I have therefore confined myself to that type of machine, and to tandems built on the same general lines.

It must not be inferred from this that front driving machines have no value; on the contrary, they deserve a more complete discussion than my limited experience with them is capable of producing.

Readers who wish for a more comprehensive treatment of cycles of all kinds are referred to Mr. Archibald Sharp's well-known work *Bicycles and Tricycles.*

The present work is intended to help riders to understand their machines, rather than to assist manufacturers.

In speaking of manufacturers, I may say that I have no interest of any kind in the cycle trade, and am, indeed, quite unknown personally to any one connected with it.

It has been found necessary to mention the names of certain manufacturers rather frequently, but it must not be supposed that those whose names are not mentioned are really less important. It merely happens that their machines do not present peculiarities that serve the purpose of the book, and it may be remarked that the absence of special peculiarities, other than a simple design combined with good material and workmanship, is often an excellent recommendation.

With regard to "Free Wheel" machines, I have used the word Pedals instead of Wheel, as I have found that many people do not understand the meaning of the term "Free Wheel," until it is explained that it is a device for giving Free Pedals when running downhill.

It is quite evident that all the makers are going in for this device for 1900, and it has been suggested that, under the circumstances, I have dealt rather scantily with the subject. However, I feel that *at present* there is very little more to be said that is worth saying, as the subject is still in the experimental stage. It seems probable that a back-pedalling rim brake, actuated by one of the two methods described in the text, will become the standard thing, and the freeing mechanism for the wheel will be either a roller-friction-clutch of the original Cheylesmore type, such as Morrow's, or a ratchet, more or less similar to that used on the "Whippet." It is in the durability of these clutches and ratchets, running, as many of them do, on a very narrow plain bearing, that the chief uncertainty lies.

No attempt has been made to even mention the endless fittings and contrivances that crop up every year under the head of "Novelties," unless they happen to have a special bearing on the subject in hand, as they will be found enumerated and briefly described every year in Mr. Sturmey's Annual, *The Cyclist's Indispensable Handbook*.

Finally, I wish to express my indebtedness to my assistant, Mr. Alexander Swanson, for his valuable assistance in the preparation of the figures in the text, and to Professor Barrell, of University College, Bristol, for his kindness in reading and correcting the proofs.

H. A. GARRATT.

London,
August 1899.

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CHAPTER I

THE ROADSTER BICYCLE

THE FRAME

FIG. 1 represents the general form of the frame as now almost universally adopted. The piece *A B* is the Steering Socket or Head, and inside it turns the main steering

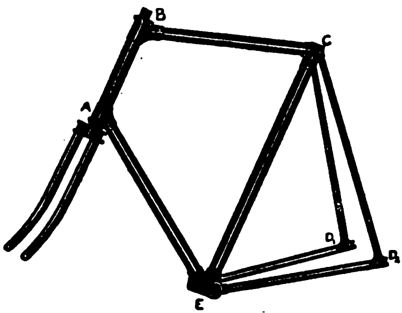


Fig. 1.

tube, which at the top carries the handle-bar, and at the bottom the crown of the front wheel fork. The corner *C* is arranged to carry the saddle pillar, and therefore a large portion of the rider's weight also. At the corner *E* is what is known as the Bottom Bracket, and into it the bearings for the crank spindle are fitted. This bottom bracket is a most important part of the frame, as will be seen later on. $C D_1$ and $C D_2$ are the stays by which the weight of the rider is mainly transmitted to the back wheel; we will call them the Seat Stays. $E D_1$ and $E D_2$ connect the bottom bracket to the centre of the back wheel, and will be called the Chain Stays. *A E* connects the bottom bracket to the lower end of the head, and will be called the Front Tie. *B C* connects the top of the head to the point *C*, and will be called the Top Strut. Finally, *C E* connects the point *C* to the bottom bracket, and will be called the Diagonal.

Chief Points aimed at in Designing a Frame. It is necessary, in the first place, that the connection between the handle-bar pillar at *B* and the crank spindle should be as rigid as possible, so that when riding up hill the effort exerted by the arms and legs may not be wasted in merely springing the frame between these points.

Again, it is of the utmost importance that the connection between the bottom bracket and the centre of the back wheel should be as rigid as possible, as any spring here not only means loss of energy, due to the fact that some of the work put into the pedals is expended in springing the frame out of shape, but there is another and more serious loss due to the chain or other gear getting out of line and so working badly.

Finally, the frame must be strong enough to carry the weight of the rider, and resist successfully the multitudes of shocks to which it is subjected on the road.

These three points will be dealt with consecutively.

Connection between B and E. Imagine the diagonal *C E*, Fig. 2, to be rigidly fixed, and suppose a man to sit on the saddle and push at the pedals with his full strength. This will have the effect of relieving the saddle of his weight, the pedals taking it all. There is also a considerable pull at the handles, which is necessary to enable him to exert a force greater than his own weight.

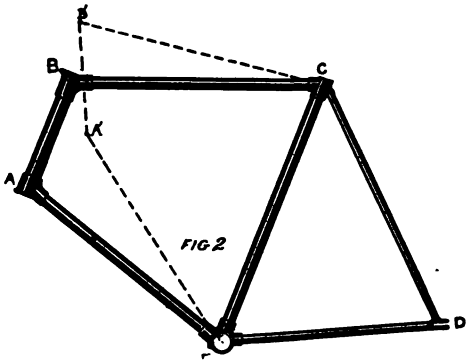


Fig. 2.

If, now, the joints *A B C* and *E* were hinged, this force would tend to pull the frame out of shape in the manner indicated by the dotted lines Fig. 2. This is prevented by making the joints stiff and the tubes of large diameter to resist bending, though the introduction of a diagonal from *A* to *C* or *B* to *E* would serve the purpose better and relieve the joints of these bending stresses. It will be obvious on examining the figure, that to pull the frame out of shape in the manner indicated, the diagonal *B E* of the quadrilateral *A B C E* must be lengthened and the diagonal *A C* shortened. One or other of these diagonals is occasionally to be found in the frames of tandems.

Again, referring to Fig. 3, suppose the man to be pushing hard on the right pedal. Now, as the force is applied at a point several inches outside the central plane of the

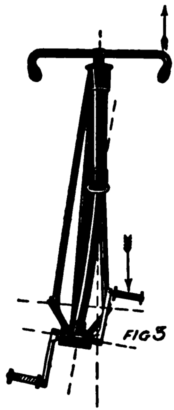


Fig. 3.

frame, there is a tendency to bend the frame sideways in the manner indicated. The rear part of the frame helps to some extent to prevent this, but still it is desirable to make the front part as rigid in this direction as possible.

What is usually done is to make the tubes of large diameter, so as to increase their resistance to bending, and to make the joints as strong as possible. Fig. 4 suggests a method by which additional stiffness could be obtained, the diagonal *B E*, which is in tension, being made in duplicate and spread out as widely as possible at the bottom. This involves two additional lugs[1] on the bottom bracket, and is probably not worth doing except in very high frames. The design of the well-known "Elswick" frame is to some extent similar to this, but it is the front tie *A E* that is duplicated, and there is no diagonal *B E*.

Turning now to the second point, namely, the connection between the bottom bracket and the centre of the back wheel.

The problem here is to connect the cylindrical bottom bracket with the spindle passing through the centre of

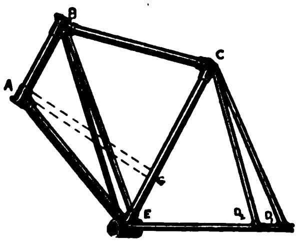


Fig. 4.

the back hub in such a way that they will not move appreciably relatively to one another.

In considering this problem it must be borne in mind that the seat stays and diagonal form part of this connection, hence the joints at D_1 and D_2 should be thoroughly stiff. The simplest, and at first sight the most obvious way

[1] A "lug" is a projecting piece or "boss," either hollow or solid. The corner pieces of the frame are often called "lugs," though only the projecting parts formed upon them are strictly entitled to the name.

of solving this problem is to have two tubes $C D_1$ and $C D_2$ connected rigidly at their top extremities to the corner under the saddle, one large tube from E to C, and finally two tubes quite straight and of fairly considerable diameter connecting the bottom bracket to the points D_1 and D_2. This would make a very simple and rigid structure, but unfortunately there are other things to be considered.

In the first place, it will be obvious from Fig. 3 that if the pedals can be kept in close to the frame the rigidity sideways will be increased; also, for the rider's personal comfort, it is desirable to keep the feet fairly close together, giving what is called a "narrow tread." There is, however, nothing to be gained by carrying this too far, as the legs must bestride the peak of the saddle at the top, and consequently the feet do not naturally come very close together, and it is a mistake to spoil the construction of the frame for the sake of a small fraction of an inch in the tread, which can only help the rider by appealing to his imagination, a somewhat difficult thing to eliminate when comparing things of this sort on the road.

Again, in the ordinary chain-driven bicycle there is a chain-wheel of some considerable diameter to be got in on one side of the bottom bracket. This makes it practically impossible to get a straight tube from D to E, so as to clear both the chain-wheel and the tyre by a sufficient amount, hence some kind of bend is nearly always introduced into the chain stay on the driving side, though there is no reason for having one on the other side, and its existence there on many machines is due, the author supposes, to sentiment about symmetry. In some machines in which the tread is not very narrow and the chain wheel of moderate diameter, bends are entirely avoided by having two small tubes one above the other, or a single tube very much flattened, so as to take up but little space sideways. These methods, however, possess disadvantages of their own, for although they give the chain stays great stiffness in a vertical plane, they weaken them in a horizontal plane, and unfortunately it is in the horizontal plane that stiffness is mainly required to resist the lateral movement of the bottom

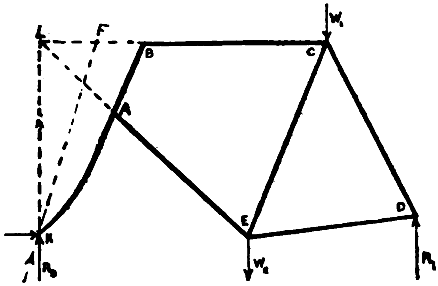


Fig. 5.

bracket under the action of the forces applied at the pedals. The design of these stays will be returned to and fully discussed in the next chapter.

Coming now to the third main feature in the design of the frame, namely, its strength when regarded as a girder supported at the centres of the wheels and loaded with the weight of the rider.

Fig. 5 represents diagrammatically the state of affairs. At the corner *C* there is a weight, W_1, which would at times be the whole weight of the rider. At the corner

E there is the weight W_2 carried by the pedals, which can also be the whole weight of the rider. There is sometimes a small weight at *B*, due to downward pressure on the handles. Finally, the frame is supported by the two reactions R_1 and R_2, of which R_1 is much the greater.

We will for the present regard the frame as if loaded in this manner, but, as will be shown presently, the magnitude of the external forces that the frame is called upon to resist is much greater than these weights. Consider first the rear part of the frame, namely, the triangle *C E D*.

It will be obvious that the joints are not liable to be deformed under the action of these purely vertical forces, as even if they were all hinges the triangle could not be pulled out of shape without altering the length of one of its sides, and there is no difficulty in preventing such alterations from being of any appreciable magnitude.

Turning now to the front part of the frame. As explained by Fig. 2, this only retains its shape by virtue of the stiffness of its joints, unless one of the diagonals be put in, making it into a pair of triangles. If, however, the line of action of the force R_2 passes through the point *L*, where *C B* and *E A* would intersect if produced, the front part behaves as if it were a triangle *L C E* and the joints are relieved of bending stresses. This is a little bit of mechanics, which is explained in all good books on that subject.

The direction of the line of action of R_2 varies considerably. When riding along a smooth road it is nearly vertical, but if the wheel strikes a stone, or in any other way receives a check, it becomes inclined backwards, as shown by the dotted line *K F*, and bending stresses occur in the corners of the frame. Unless the frame is exceptionally high, the position of *L* may be selected so that the vertical through *K* falls a short distance *in front* of it, thereby making a compromise between the conditions when at rest, and those when striking some object such as a stone or lump in the road.

If the frame is very high, the point *L* comes too far forward, and it is desirable to put in one of the extra diagonals, preferably *B E*, to relieve the corners of the frame and stiffen the connection between *B* and *E*.

Height of the Frame. In a high frame the stresses in all the chief members are less than in a lower frame carrying the same weight, but a high frame is more difficult to keep true sideways, particularly if the head is very long and the front quadrilateral unbraced by diagonals. What happens is this: the joints and tubes take a slight "permanent set," causing the head to be out of line with the diagonal *C E* when looked at from in front or behind. Some makers, in cases of this kind, put in an additional tube parallel to *A C* connecting the bottom of the head to the diagonal *C E*; but if an additional tube has to be introduced, it would surely be better to brace the front quadrilateral by means of one of its diagonals as is usual in engineering structures. The diagonal *B E* may be a little awkward on account of the extra lug on the bottom bracket, but to connect *A* to *C* should present no difficulty. The above remarks refer only to machines built for very tall riders, in ordinary cases the matter is not of sufficient importance to warrant any additional tubes being put into the frame.

Effects of Shock. It was mentioned above that the magnitude of the external forces acting upon the frame is much greater than that represented by the weights carried. This will be made evident by the following simple experiment. Hang up an ordinary spring balance to a hook and place a weight of, say 4 lbs., gently in the pan. The spring will be stretched until the pointer indicates 4 lbs. Now put the weight on suddenly, but without actually dropping it into the pan from any appreciable distance, and it will be observed that the pointer goes down to about 8 lbs., and oscillates backwards and forwards until it finally comes to rest at the 4 lbs. again, but the 8 lbs. mark indicates the extent of the strain momentarily produced in the spring. Finally, drop the weight into the pan from a height of a few inches, and it will be seen that the momentary strain is still further increased. Given the height through which the 4 lbs. is dropped, the dimensions and what is called the "coefficient of elasticity" of the spring, an engineer can calculate the strain produced in the spring.

If, now, a bicycle travelling fast passes over a stone, the wheels are given a sharp blow which throws them up and causes them immediately afterwards to come down on the road with a crash. Here we have a case similar to the weight dropped into the pan, but complicated by a great many additional circumstances which baffle exact calculation. Practically, the strength needed at all critical points is determined by experience, of which there is now no lack, calculations being confined to arranging the material so as to give a maximum of strength for a minimum of weight.

CHAPTER II

THE ROADSTER BICYCLE (*continued*)

DETAILS OF FRAME

Joints. The importance of good joints will be obvious after reading the foregoing pages. They are usually constructed in one of the following ways.

Stamped Corner Pieces or "Lugs" (**see Fig. 6**). By this method a solid piece of steel is brought to the required external shape by being stamped between dies when hot.

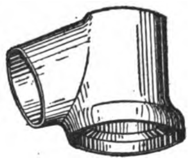


Fig. 6.

Holes are then bored at the correct angle and to diameters exactly fitting the tubes to be connected. If these stampings are made of good steel, they make an excellent job, but they are expensive, as such a quantity of material has to be removed from them before they assume their finished form.

Malleable Castings. This is a cheaper method and is much used. The lugs are turned out from the foundry hollow and nearly the right thickness, and so require very little work to be done to them afterwards. The material is, in the first place, ordinary cast iron, but it is subsequently put through a process which removes a large portion of the carbon present in the cast iron, leaving it in a state more or less resembling steel. If the iron is of suitable quality to start with, and the subsequent process is well carried out, the finished article is fairly tough and will stand a good deal of bending without fracture. These castings are scarcely equal to good steel stampings accurately machined up, but still they do very well, and help to make it possible to turn out very good machines at a moderate price.

Lapped Tubes. Some makers construct the corners of their frames by working the ends of the tubes around one another, in a manner that will be described more fully when dealing with handle-bars and seat pillars. This method has its good points, but when it is used for such corners as *A* and *B* an additional fitting has to be attached, to carry the ball races for the bearings of the head. When ordinary lugs are used, they are recessed so as to hold the hard steel ball races in a manner that will be described in detail later. These lapped tubes also cannot be "reinforced" near the corners in the same satisfactory manner as ordinary tubes fitting into lugs.

Method of Connecting Tubes to Corner Pieces. The usual plan is to braze the tubes into the lugs or corner pieces. The frame is built up on a special table with vices which hold the parts in their proper positions; small holes are then drilled and pins fitted in to keep the parts from moving during the process of brazing. The brazing is usually done by means of a gas furnace, powdered borax being used as a flux.

This method was all very well in old days when the tubes were comparatively thick, but now when they are often only 22 gauge, which is equivalent to a thickness of not quite $\frac{3}{100}''$, the softening of the tube due to the heating, and the subsequent cleaning off of the superfluous brazing solder and hard glaze formed by the borax, are apt to injure it considerably, and the author has known of several cases of machines breaking right in half from this very cause. Two machines by the same maker broke in this way within a few days of one another, both having been in use for about eighteen months. It need scarcely be pointed out that this is a most dangerous kind of accident.

In the author's opinion, the best way to get over this difficulty is to "shrink" a piece of tube some 4 or 5 inches long onto the outside of the main tube at each end, as is done in the "Osmond" bicycles. This strengthens the tube in exactly the way needed, and protects it during the process of brazing and the subsequent cleaning.

Some makers fit tubes or "liners," as they are called, inside. They are then invisible, which may be considered an advantage by some people, though not by the author. Inside liners are apt to be fitted in a slovenly way, and they do not protect the tube during the cleaning and polishing process. Some machines, notably the "Elswick," are constructed with flush joints, which make a remarkably neat job, especially when the tubes are of small diameter. In an extremely high class machine like the "Elswick," these hidden joints and liners may be right enough, but they involve a certain amount of faith on the part of the purchaser, which, if extended to the trade at large would often be misplaced.

Recently tubes thickened at the ends, and forks graduated in thickness, have been introduced by the Patent Butted Tube Co. Ltd. of Birmingham. This certainly seems to be a step in the right direction, and it is to be hoped that extended experience will show that this method of manufacturing tubes is as good as it seems to be.

Mechanical Joints. Recently, machines made by Messrs. Humber & Co. have had their principal joints connected without brazing (see Fig. 7). A tapered bolt passes through the outer lug, the main tube and an inner split liner. This bolt is surrounded by a sort of split strut as shown. On tightening the nut and drawing the bolt in, this strut and the inner liner, and tube also, are expanded, making the whole rigid. The author confesses to a certain amount of prejudice against mechanical connections of any sort at the corners of bicycle frames, and does not think the case against brazing bad enough to justify the additional nuts and bolts. This, however, is merely a personal opinion and must be taken for what it is worth, but it must be remembered that one object he has in view is to encourage the construction of machines of such simplicity that they may be ridden pretty constantly by entirely unmechanical persons without being a nuisance to them. Looked at from this point of view, every additional nut, bolt, or screw, that can by any possibility work loose and require looking after, must be justified by some real advantage *to the rider* before it can be tolerated. When the frame is constructed of aluminium or any other material that cannot be

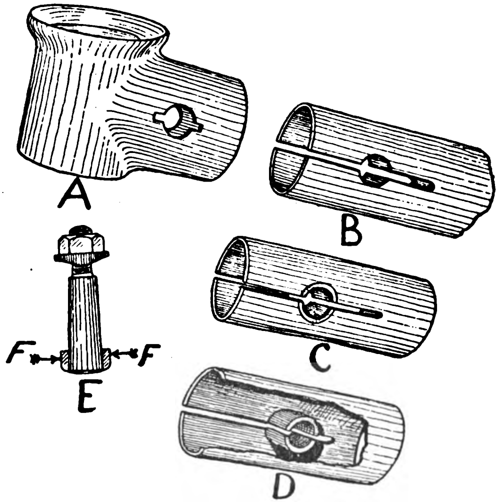


Fig. 7.

(A) is lug, showing hole for bolt.
(B) is end of main tube, showing split and hole for bolt.
(C) is split liner that goes inside tube.
(D) is another view of liner broken away to show split strut inside. The hole through this strut is tapered.
(E) is tapered bolt, which expands liner and tube when drawn into the strut.
(F) are lugs on bolt head to prevent it turning round.

satisfactorily soldered, the mechanical joint has, of course, a special advantage.

Jointless Frames. There are one or two firms making frames which are cast all in a piece, in some alloy of aluminium. Such frames need not be enamelled, and therefore do not get shabby and require re-enamelling, and they cannot, of course, rust. They also have the advantage that the tubes can be made of considerable thickness without being unduly heavy, and so they are much less likely to get dinged in. It must be remembered that although pure aluminium is a soft, weak material, some of its alloys, especially with copper, are far otherwise. The aluminium bronzes used for engineering purposes are nearly as strong as mild steel, but in these the copper largely predominates, and consequently they are not par-

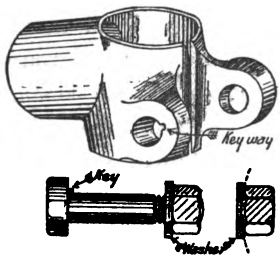


Fig. 8.

ticularly light. Extreme lightness is, of course, the most attractive quality in aluminium from a bicycle-rider's point of view, one cubic foot of it weighing only 162 lbs., whereas a cubic foot of steel weighs about 490 lbs. The author would gladly see nickel-plating, enamel, and their usual companion, *rust*, disappear into permanent oblivion, unless makers can be induced to give more attention to doing the first two properly, and so getting rid of the third.

Connections at Corner C (see Fig. 1). The usual form of this joint is shown in Fig. 8. It may be either a stamping or a casting, and the tubes *B C* and *E C* can be connected to it by either of the methods already described. The joint has, however, to perform the additional function of holding the adjustable seat pillar, which slides inside the diagonal *C E*. This is almost always accomplished by slitting the lug and the diagonal down the back for about a couple of inches, and closing them round the seat pillar by means of the very familiar bolt. This bolt also serves to carry the ends of the seat stays, though, as will be pointed out later, this is not necessarily the best way of fixing them (see Design "*G*"). The bolt ought to have a little pin or key under the head, fitting into a suitable recess, so that it does not turn round when the nut is tightened. The nut also should be spherical on its inner surface, and should rest on a spherically hollowed washer, so as to ensure its "bedding" truly, even when the lugs through which the bolt passes draw together a little and so cease to be parallel to one another. These details are clearly shown in the drawing.

Connections at Corner D. We will now examine the joint *D*, which is one of considerable interest, as with it we have to combine some method of adjusting the chain. As will be explained later, if full advantage is to be taken of the material put into the seat stays and chain stays for the purpose of securing a rigid connection between the back wheel spindle and the crank spindle, these stays should be connected together at the point *D* in a thoroughly substantial manner. Connections made up of *thin* extensions of the tubes or pieces brazed thereto are bad; when in addition they have sharp bends in them they are worse; and when in addition to these two faults, the seat stays are connected by small screws, they are, from a rider's point of view, quite inexcusable.

One of the best connections used at this corner is that of the "Osmond" bicycle, as shown in Fig. 9. Here the seat stay is lapped round the extremity of the chain stay and brazed, a thickening piece being put on the inside as shown. With this is combined a singularly neat chain adjustment. The end of the spindle screws into a round nut, which fits inside the extremity of the chain stay, and

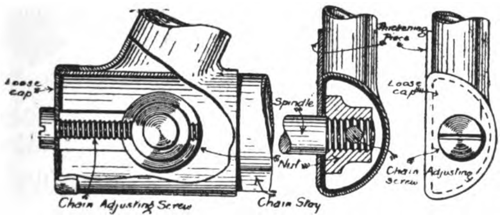


Fig. 9.

the chain-adjusting screw passes through both the spindle and this nut, being screwed through the former. The head of the adjusting screw takes its bearing against a loose cap, which covers the end of the chain stay, and, it will be observed, remains in the same position for all degrees of adjustment. There is consequently never any untidy-looking screw projecting behind, in the manner so common on many machines. The lock-nut (not shown in Fig.) for fixing the back wheel spindle after adjustment is on the inner or hub side of the stay, and nips the inside thickened section of the D tube between itself and the round nut concealed within. There is consequently no fear of losing this lock-nut, a misfortune that occasionally occurs with the outside nuts. In the most recent pattern of this machine, a special form of spindle is used in the hubs (see Design "*H*," Plate IV.), which entirely does away with the lock-nut on the driving side. This is a distinct advantage, as the inside nut on that side was very awkward to get at when the machine was fitted with a gear-case. These inside nuts make the attachment of the step and splash-guard stays a little awkward, and it will also be noticed that this form of adjustment will not slacken the chain, but only tighten it.

Design "*G*," Plate II., illustrates another form of back corner and chain adjustment. In this case the chain and seat stays are round, and have brazed into their extremities steel stampings of special shape. In these pieces there is a $\frac{5}{16}''$ slot, in which the end of the spindle slides. The spindle is $\frac{3}{8}''$ diameter over the screw thread, but has two flats cut upon it at this point, taking away little more than the thread. These flats carry the weight, and so the screw thread does not get damaged; they also prevent the spindle from turning round, and thereby remove any chance of disturbing the adjustment of the wheel bearing when adjusting the chain. The chain-adjusters slide in two grooves cut in the faces of the $\frac{5}{16}''$ slot, the screwed part going into a hole bored through the solid part of the steel stamping into the tube beyond. A round steel nut is slipped into another slot $\frac{7}{16}''$ high and $\frac{1}{4}''$ long. When the chain-adjuster is in place this nut can only turn round, and in doing so it moves the chain-adjuster one way or the other. There are four holes drilled radially into the nut, so that it can be turned by a peg key for small adjustments, while its milled edges enable it to be turned rapidly with the fingers when taking the wheel out, everything then being quite slack. The special features of this design are, firstly, apart from the two main nuts, there are no fittings that can possibly work loose and drop off. It is consequently unnecessary, after tightening the nuts on the main spindle, to give the small adjusting nut that final fraction of a turn which is required on most machines, and, being often forgotten, is the cause of many lost nuts and fittings. Secondly, the screwed part of the adjuster is neatly tucked away and cannot get bent or otherwise damaged, nor when the chain has stretched a good deal can it ever stick out behind in the manner so common with the ordinary arrangements. Thirdly, it adjusts both ways. This is a point of some importance, as very few chains are equally tight in all positions after they have been in use for some time, even if they were when new. Hence, unless the adjustment happens to have been made with the chain in its tightest position, it may turn out to be a trifle too tight somewhere or other, when tested by spinning the wheel round, and consequently a little slackening will be required, which is very awkward to carry out with exactness by pushing the spindle.

Fig. 10 shows a very usual form of joint and chain adjustment, which has become well known through its use on "Humber" bicycles. Here the spindle of the back wheel is carried in the ends of the seat stays, which swing back with them, as the chain is adjusted. This insures the thrust in the seat stays being truly axial, but prevents that in the chain stays from being so. The advantage on this score is therefore negligible, if not negative. This design admits of the connections being made without any additional stampings or castings, the extensions being merely worked out of the tubes, an additional thin piece of metal being put inside to increase the thickness of the flattened ends. In Fig. 10 a collar nut is shown, this

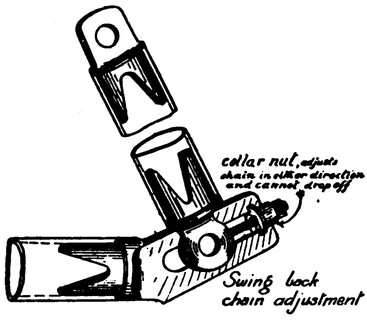


Fig. 10.

tightens or slackens the chain in a manner similar to the arrangement in Design "*G.*"

Parallel Chain Adjustments. From time to time attempts have been made to introduce for the chain adjustments which move both ends of the back spindle evenly and at the same time. In the author's opinion the advantage of this is apt to be very much exaggerated. Parallel adjustments are apt also not to be what they are designated, and then they are only "gay deceivers." About eight years ago the author had a machine by a fairly well-known maker, in which the extremities of the back wheel spindle were D-shaped and an eccentric disc was slipped on at each end. The chain was adjusted by turning the spindle round by means of a spanner applied to a square at one end, the eccentric discs then pushed both ends of the spindle back, by pressing against little pegs on the inside of the frame. The thing was well made, but had several faults. In the first place, there was always a risk of disturbing the adjustment of the bearing; secondly, there

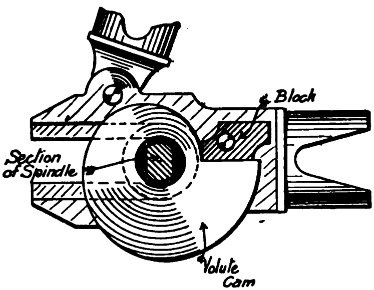


Fig. 11.

was nothing to keep the discs pressed up against their respective pegs, and if one happened to move away from its peg a little, the adjustment turned out crooked; thirdly, unless both the discs fitted on to the D ends of the spindle with precisely the same degree of tightness, the arrangement ceased to be parallel. One way and another the author found it much less convenient than the ordinary plan, and was surprised to find it unearthed this year by the Birmingham Small Arms Company.

Fig. 11 shows clearly the form it has taken in their hands. They have substituted a volute cam for an eccentric disc, which is an improvement, and the peg is made capable of a certain amount of adjustment, so that the wheel may be set true in the fork to start with more easily than was the case with a fixed peg; perhaps in this revised form the arrangement may have a new lease of life, for it is remarkably neat, and there is nothing about it that could very well get lost or damaged. It will be noticed that this adjusting gear cannot be used to slacken the chain.

Another form of parallel adjustment, much used for adjusting the front chains of tandems, is shown in Fig. 12.

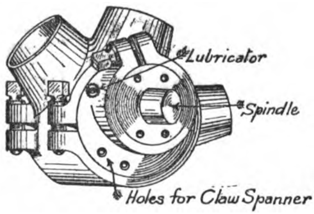


Fig. 12.

This really belongs to the next corner of the frame, but can conveniently be inserted here. It is known as an "Eccentric Bottom Bracket," the crank bearing being contained in an inner cylinder fitting eccentrically into an enlarged bottom bracket. It is clamped in position by split lugs and bolts as shown, the adjustment being effected by turning the inner cylinder round by means of a claw spanner or otherwise. It will adjust in either direction and is always perfectly parallel. The author has had one of these arrangements for years on a tandem, and has found it so remarkably satisfactory, that he has been surprised that it has not been more used on single machines. The crank bearing itself, not being brazed into the frame, has not that opportunity of getting warped out of truth, and as there are no lugs opening into the inside of it, the oil cannot stray into the frame, and so get dirty if the machine is turned upside down. It is advisable to have the bearing projecting somewhat on the left side, so as to enable a hole for oil to be drilled through at an angle, thus entering the bearing just beyond the cup.

Length of Chain Adjustment. This must be sufficient to enable a link to be taken out of the chain, and the wheel put back again to the beginning of the slot, when the extent of the adjustment is exhausted. There is no object in having more than this, but if there were any less and a link were taken out, the chain would not go on again when the wheel was pushed back. The actual amount required is a trifle more than half the length of the link that would have to be removed. For instance, in an ordinary inch pitch block chain one has to remove one block and a pair of side links, the length of which together, measured between the end centres, is the pitch of the chain. It is important not to remove the pair of side links through which the connecting screw passes, as the hole in one of these links is threaded on the inside to suit the screw.

Bottom Bracket. We will now pass on to the bottom bracket, treating it as part of the structure of the frame, the bearings it contains being dealt with in Chapter V.

In most bicycles the bottom bracket is a malleable casting, though stampings are used on some high-class machines. These latter are costly pieces of work, as in a stamping, not only are the projecting lugs solid, but also the main cylinder, and consequently a great deal of material has to be machined out before it is reduced to the thin hollow bracket that is finally obtained (see Fig. 13).

It is a matter of great importance that the lugs should all be bored to the correct angles, and a special machine tool is used to perform this operation.

The various tubes are connected to their respective lugs

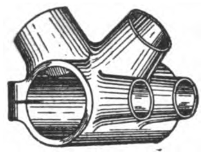


Fig. 13.

by one of the methods already explained, and other work has to be done on the bracket for purposes connected with the ball-bearing that goes inside. Some makers have formed the bottom bracket out of a short piece of steel tube of large diameter, three of the lugs being formed out of the tube itself, while the fourth tube is flanged out to fit against the cylindrical bracket and brazed, a sort of "thimble" being put up the tube from the inside of the bracket to strengthen the connection.

When the bracket is not lined inside with a separate tube, it is as well to plug the open ends of the lugs inside the bracket with tightly fitting corks. This prevents the oil in the bearing travelling about the inside of the frame when the machine is turned upside down for cleaning or repairing tyres; it also prevents the balls from doing likewise when the bearing is being put together.

The Connecting Limbs of the Frame. Before entering upon the details of this subject it will be as well to consider the strength of tubes in a general way.

In the first place, if a tube or rod be subjected to a *direct pull* of, say, 100 lbs. there is what is called a tensile "stress" set up in the material of the tube. This stress is measured, as a rule, in pounds per square inch of sectional area. For instance, suppose the sectional area of the tube to be $\frac{1}{100}$th part of a square inch, the stress produced by the 100 lbs. would be 10,000 lbs. per square inch. This stress necessarily involves also an alteration in the length of the tube, called a "strain," the strain being measured as the ratio of the increase in the length to the original length. The ratio of this stress to this strain is called the "coefficient or modulus of direct elasticity" of the material, and is a measure of its stiffness, depending solely on the nature of the material itself. If the tube were overloaded it would take what is called a "permanent set," or in other words, it would be strained beyond its "elastic limit," and would not recover its original shape on the removal of the load. It will be fairly obvious that to resist a pull the limb of the frame should be straight, as any bends involve additional weight and a lack of rigidity, though to resist a pull pure and simple, *a tube* possesses no special virtue as compared with a solid rod or wire.

In the second place, the tube might be subjected to *twisting* by having one end fixed firmly into a socket held in a vice, and a double ended pipe wrench applied to the other end (a single ended one would not do as it would produce bending as well). Now, it is a fact well-known to engineers, and easily proved mathematically, that, weight for weight, a tube of simple circular section is the very best thing possible to resist forces applied in this way, and, if the rod has to be solid, a plain round rod is the best thing. A square section is scarcely any stronger than the circular section that will go inside it, the corners being almost useless for resisting twisting. An oblong section is weaker than a square of the same weight, and the more oblong it is the weaker it becomes.

In the third place, suppose the tube to be supported at two points some considerable distance apart, and a weight to be hung at its centre or elsewhere so as to tend to bend it. The material along the top surface is compressed and that along the under surface stretched, there being an intermediate layer of material known as the *neutral plane,* where the stretching dies away and the compression begins, and in this place there is neither tension nor compression. In addition to this tension and compression there is a vertical stress called "shearing," which resists the tendency of the particles of the material to slide over one another in a vertical direction. For reasons that cannot be explained here, this stress is greatest at the neutral plane, and dies away to nothing at the top and bottom surfaces.

It follows from this that, in order that our tube shall resist bending well, we must accumulate a fair proportion of its substance at some distance from the neutral plane, where it can better resist this bending process, and keep only such material near the centre as is required to resist shearing, which is not as a rule a very arduous duty. This means that we must flatten our tube into some sort of oblong shape.

There is, however, another thing to be considered namely, that it is very easy to so alter the shape of a section that although it will deflect less under a given load, yet it will break more readily than before. This would occur if a thin fin were extended out along the top or bottom surface of our tube, whereby we should get a small quantity of the material a very long way from the neutral plane. This material would offer a very stubborn resistance to bending so long as it could hold out, but there being very little of it there, it would break comparatively easily.

The resistance to deflection is called stiffness, and the resistance to fracture strength.

In some parts of a bicycle frame stiffness is the chief thing to be aimed at, while in others stiffness is less important, and strength only need be considered.

In Fig. 14 are given a number of different tube sections together with figures indicating their relative strength and stiffness, the plain tube being taken as the standard. All the tubes have the same amount of material in their section, and consequently have the same weight for a given length. It will be noticed that maximum and minimum values are given for all sections

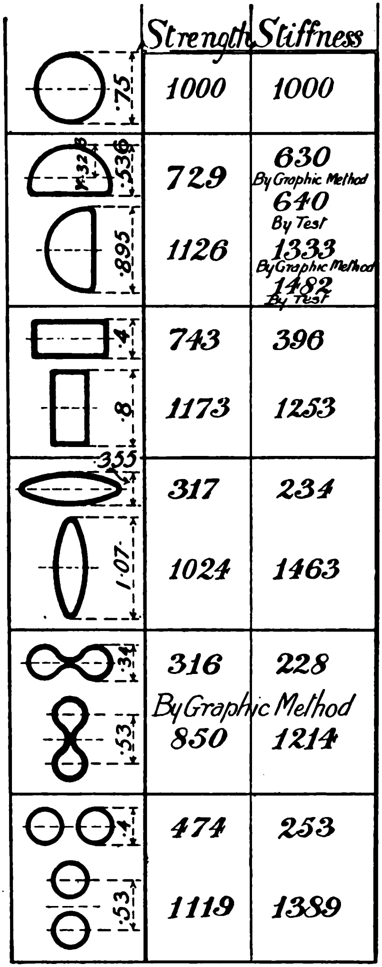

Strength
Stiffness
·75
1000
1000
·536
·328
729
630
By Graphic Method
640
By Test
·895
1126
1333
By Graphic Method
1482
By Test
·4
743
396
·8
1173
1253
·355
317
234
1·07
1024
1463
·34
316
228
By Graphic Method
·53
850
1214
·4
474
253
·53
1119
1389

Fig. 14.

except the plain round one; this is because all the others are weaker when bent in one direction than when bent in some other. The strength depends on a certain function of the dimensions of the cross section, known as its "modulus," and the stiffness on a somewhat similar function known as its "moment of inertia."

The results for the D and fluted sections were obtained by the Graphic method, and those for the other simpler sections by the ordinary method. With a view to testing the accuracy of these results the author has endeavoured to get straight lengths of tube of the sections shown, or or at any rate of similar sections. He has, however, been unable to do so, except in the case of the plain round and D tubes, the difficulty being to get a set of tubes all made from the same gauge steel, and weighing the same per foot of length. The round and the D tubes were almost precisely the same weight and gauge, and the results obtained by measuring and comparing the deflections of these, are very fairly in accordance with the calculations.

In the fourth place, let us suppose our tube to be set up on end and loaded like a pillar. It will be found now, if we increase the load sufficiently, that the tube will suddenly collapse by buckling and will not quietly crush as a short block would if subjected to the same treatment. This buckling is enormously facilitated if the tube is not straight, or if the load is applied to one side of its centre line or "axis," as then there is an obvious bending tendency to start with.

Again, the method of attachment at the ends has a most important influence on the strength of a "strut,"

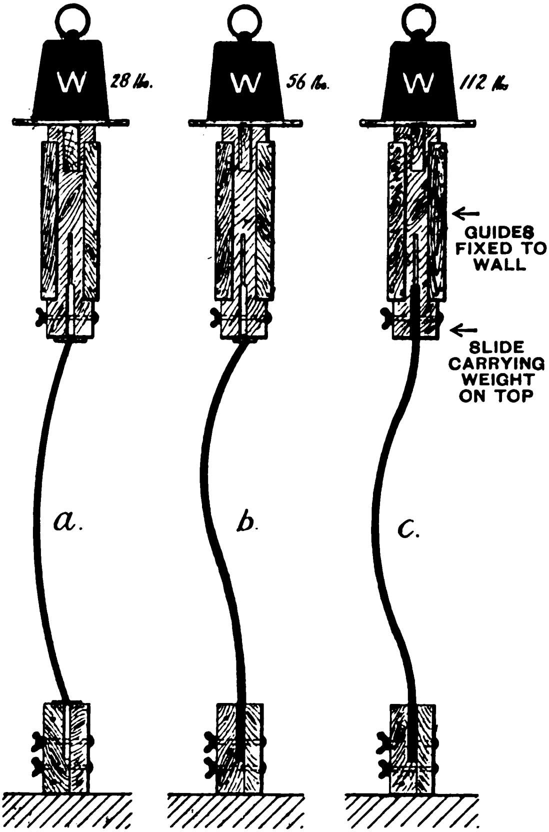


Fig. 15.

for that is the usual name given to a portion of a frame subjected to a load of this kind. In order to avoid using a mathematical investigation which would be quite out of place here, the author will give a short account of a simple experiment which he makes use of to demonstrate this point to his students in Applied Mechanics. The apparatus used is shown in Fig. 15. In the first experiment a clean grained piece of wood 5′ 0″ long, 1¼″ wide, and ½″ thick is used. The ends of this piece are rounded and bear on slightly recessed steel plates, so that it can bend as shown at *a*. The load it will carry is barely 28 lbs., any increase causing it to buckle, and when it once begins buckling, it continues to do so until it breaks, without any addition being made to the load. In the apparatus there is a stop to prevent the buckling going too far.

In the second experiment a similar piece of wood 5′ 6″ long is used, the extra six inches being firmly gripped in clamps at the lower end, the upper end remaining as before. The load that this will just carry is 56 lbs., and when it buckles it assumes the shape shown at *b*.

In the final experiment another similar piece of wood 6′ 0″ long is used, both ends being firmly gripped, the part between the supports retaining the original length of 5′ 0″. This time a weight of about 112 lbs. is required to buckle the piece of wood, which assumes the shape *c*. Now this means that if a long strut is firmly fixed at the two ends it will carry with safety about twice as much as when fixed at one end only, and *four times* as much as when it is hinged at both ends. These facts are in accordance with the mathematical theory and general experience.

D

There is another important point to be considered in connection with these struts; namely, the shape of the cross section. The load that a column or strut can carry is proportional to its stiffness in the direction in which it will most readily yield, and this fact must be borne in mind when selecting the most economical section. A reference to Fig. 14 at once settles this question in favour of the plain circular tube, and when through force of circumstances one of the other sections has to be used, it should, if possible, be given some support in its weak direction at some intermediate point in its length. In this way it is often possible to equalize matters, as the stiffness of a long column is inversely proportional to the square of its length.

Manufacture of Steel Tubes. The great majority are made without any seam by a process called drawing. This process has been brought to a state of great perfection, and tubes so made are wonderfully smooth and uniform. When held up to the light and looked through they appear almost as smooth and bright as the barrel of a shot gun. The steel of which these tubes are made is necessarily very "mild" to stand having so much work done upon it, and attempts have been made to produce stronger and stiffer tubes out of sheet steel of a harder quality, twisted up into a tube and brazed. The author's experience with these tubes was unfortunate, and probably exceptional, and therefore he refrains from quoting figures, but it seems rather curious that one leading manufacturer should adopt special measures to avoid brazing wherever possible, while another should use brazed seams all along the tubes. That some of these brazed tubes have shown remarkably good results when tested seems to leave no room for doubt, but that it is possible to buy weldless tubes in the open market that will withstand loads that absolutely doubled up a specially prepared and slightly heavier sample of brazed tube, is a fact that on a certain occasion caused the author and his students no little surprise. Presumably the sample was defective, though no defect was discoverable, and on its being returned to the makers, at their request, no explanation was offered. A clear description of the method of drawing tubes together with illustrations of the tools employed will be found in *Engineering* of July 19, 1897.

Recently tubes made of steel alloyed with from 3 % to, in some cases, as much as 25 % of nickel have been introduced. This nickel steel seems to be an excellent material for solid drawn tubes, whether the tubes are intended for bicycles or other purposes, such as boilers.

We are now in a position to return to the consideration of our original subject, namely, the **Connecting Limbs** of a bicycle frame. Beginning with the Top Strut *B C*; this is in compression, but liable also to bending near the ends as indicated in Fig. 2. Hence it should be, as in fact it is, a tube of considerable diameter firmly fixed at both ends and quite straight. Taking the Steering Socket *A B* next, we find in most machines a tube similar to the Top Strut, but of somewhat larger diameter in order to give room for the steering tube within the socket. This tube has to resist very similar treatment, and is therefore quite suitable. Coming now to the Front Tie *A E*; this is subjected mainly to tension, though liable at times to be put in compression—*e.g.* when the machine runs into a wall—it must, however, be capable of resisting a good deal of bending near its extremities for reasons indicated in both Figs. 2 and 3. On the whole the large tube usually found here seems suitable, though there is a good deal to be said in favour of two smaller tubes spread out widely at the bottom bracket as used in the "Elswick" bicycles.

Passing on to the seat stays we get to more debatable ground. In the design illustrated by the drawings marked *G*, Plate II., in this book, these limbs are quite straight and of plain round section except for a few inches at the bottom end on the driving side, where there is a little flattening on the inside to accommodate the gear-case. These tubes are firmly fixed at both ends, and the end connections are arranged so as to keep the line of thrust straight down the axis of the stay, they are consequently made lighter than usual. The usual attachment at the top is by means of the bolt that holds the seat pillar in position, and no doubt this method is very convenient, but unless the bolt is extremely tight it can scarcely be regarded as a rigid connection. At the bottom end the Design "*G*" does not differ from many in actual use, but at the same time it may be remarked that it *does* differ very much from many others also in actual use, and to which the remarks on page 18 were intended to refer. With regard to the plain round section, the author sees no reason for using any other, and when that which is simplest and cheapest is also best, there is no need for discussion. A tubular bridge is sometimes brazed to the stays a few inches above the wheel to carry the splash guard, and although very convenient for that purpose, it cannot be looked upon as of any assistance to the stays unless it encircles them, for the softening of the stay by the process of brazing will reduce its stiffness more than the bridge will increase it, if the latter is merely brazed on without any flanging. On the whole it is better to have no bridge brazed on here, unless the stays are made of tubes of elliptical or other flattened sections, in which case a properly fitted bridge stiffens them in the direction in which they would most readily yield, and is therefore desirable.

Turning now to the diagonal *C E*; it is usual to use a single large tube here, and it appears to answer well, but it is somewhat open to question whether two tubes similar to the seat stays would not be stiffer if splayed out widely at the bottom. There is sometimes a tensile, and sometimes a compressive stress in this member, but in addition, it is subjected to a considerable amount of lateral bending, which the two splayed tubes would be better able to resist than the single tube. On the other hand, if the saddle is put at the end of a long L pin, projecting either backwards or forwards, the weight of the rider tends to produce bending in this member, in a "fore and aft" direction, and for resisting this the two tubes are unsuitable; but such a position of the saddle as that referred to is due to a mere craze, and need not be seriously considered in designing a roadster for touring and general purposes.

Coming finally to the chain stays, we find ourselves on very debatable ground, which we shall to some extent traverse again when discussing the racing bicycle. At present we will confine our attention to machines of the ordinary type intended for road work and capable of taking a gear-case. Taking the left stay first, we find that there is no difficulty in making this of a plain straight tube, so by all means let us do so. In the set of drawings marked "*G*," Plates I. and II., this design is shown, except for the middle portion of the tube, which, however, is merely a continuation of the parts that are shown.

Turning to the stay on the driving side we find a straight tube no longer possible, it becomes necessary to bend the tube to clear the chain-wheel and tyre, and it is most desirable to brace this stay near the bend to the straight stay on the other side by means of some form of "bridge," which encircles the straight stay, and is not merely brazed against it. In the Design "*G*," the bend in the tube itself is avoided, and the cross-bracing accomplished by means of a steel stamping, the details of which are clearly shown. In this way we are able to use plain straight tubes, and the corner is considerably stronger than if a bent tube were used. The author regards this design as being the simplest and most economical way out of the difficulty, and simplicity and economy are obtained without sacrificing efficiency, but there are, of course, many other designs, some of which possess considerable merit, especially when the machine has no gear-case, a very narrow tread, and an unusually large chain-wheel (see Racing Bicycles).

Width of Tread. This seems an appropriate place to discuss this question. On referring to the Design "*G*," Plate I., it will be seen that the width across the crank faces is $5\frac{1}{8}''$. If the tread had been made symmetrical this would have been $5\frac{3}{8}''$, but the left-hand crank is $\frac{1}{4}''$ nearer to the centre of the machine than the right-hand one. This dimension has been arrived at in the following way. The width between the spoke flanges of the back hub is first settled; $2\frac{1}{4}''$ has been selected as the smallest dimension desirable in a full roadster. In order to leave room for a gear-case $\frac{7}{8}''$ wide and sufficient clearance between it and the spokes, it is necessary to have the centre line of the chain $1\frac{3}{4}''$ from the centre of the machine. On the outside of the chain we require, measuring from its centre, $\frac{7}{16}''$ for half the gear-case, $\frac{1}{8}''$ clearance and $\frac{3}{8}''$ for the thickness of the crank. We have then

$$1\tfrac{3}{4}'' + \tfrac{7}{16}'' + \tfrac{1}{8}'' + \tfrac{3}{8}'' = 2\tfrac{11}{16}.''$$

Multiplying by 2 to get a symmetrical tread, we have $5\frac{3}{8}''$ as stated above. The chain line might be brought in closer by increasing the diameter of the spoke flange on the driving side and taking it nearer to the centre of the hub, so as to keep the angle between the two sets of spokes the same as before, and thus avoid weakening the wheel. In old days it was a common thing to have immense spoke flanges about the size of saucers, but one day there came a craze for small flanges and the large ones had to go.

In order to see what could be done in this way and whether it is worth doing, we will examine the question of tread from another point of view. Suppose the machine to be fitted with a tyre $1\frac{3}{4}''$ diameter, *i.e.* having a radius of $\frac{7}{8}''$; add to this $\frac{1}{4}''$ for clearance between the tyre and the gear-case (this being quite the minimum desirable), and $\frac{7}{16}''$ for half the gear-case, we get $1\frac{9}{16}''$ to our chain line, which means a saving of $\frac{3}{8}''$ in the tread as compared with the $1\frac{3}{4}''$ chain line.[1] To get this the driving-side spoke flange must be moved in, until it is $\frac{15}{16}''$ from the centre of the hub, and its diameter must be increased to something like $5\frac{3}{4}''$, which, though no doubt feasible, seems rather like "straining at a gnat and swallowing a camel." In racing machines having a $1\frac{3}{8}''$ chain line, a symmetical tread may be obtained with only $4''$ across the crank faces, as will be shown later when describing the Design "*H*."

In dealing with this question, it must be borne in mind, that a reduction in tread means also a reduction in the distance between the two rows of balls in the crank bearing, which is distinctly undesirable, especially in a machine in which durability is a matter of first-rate importance. The author assumes that in a roadster durability *is* of first-rate importance and in a racer that it *is not*.

[1] The "chain line" is the centre line of the chain as seen in plan. A machine is said to have an $1\frac{3}{4}''$ chain line, when the distance from the centre of the hub to the centre of the chain is $1\frac{3}{4}''$, as measured on a plan.

CHAPTER III

THE ROADSTER BICYCLE (*continued*)

FRONT FORK AND STEERING PILLAR

FIG. 16 represents in a diagrammatical way the forces acting on the front fork and steering pillar. We have, in the first place, the force R acting at the centre of the wheel. The direction of this force may be anything from vertical to nearly horizontal; it is nearly vertical when the machine is running on a smooth road, and it is nearly horizontal when the machine runs into a wall. Bicycles are not built to run into walls, but still collisions of one kind or another have occurred in the experience of most riders, and a fork should, therefore, not be too tender, even when subjected to treatment quite different from that for which it was primarily designed; hence it is necessary that it should be capable of withstanding forces tending to double it up under the frame as well as others tending to bend it out forwards. The magnitude of these forces cannot be accurately determined, the strength necessary at the critical points being, as usual, settled by experience. It remains to decide on the most economical way of distributing our material, so as to give the required strength with the minimum of weight.

It is evident that the liability to bend, or what engineers call the "bending moment" due to the force *R*, increases from the bottom up to the first support, which is the row of balls at the bottom of the head. This liability to bend at any particular point is directly proportional to the leverage with which the force *R* acts with respect to that point. This leverage is the distance from the point to the line of action of *R*, measured in a

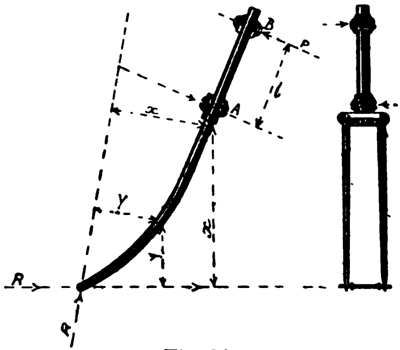


Fig. 16.

direction at right angles to that line of action, and it is indicated by the letters x and y in the figure.

Turning now to the steering pillar *A B*. This is held in position by the two rows of balls, the distance between them being called l, and there is a force *P* acting at *B* of such magnitude that

$$P \times \textit{leverage } l = R \times \textit{leverage } x.$$

The liability of the tube *A B* to bend increases from the top to the point *A*, which is the critical point of the whole structure.

Having thus disposed of the general principles, we will now turn to details. The tube *A B* should obviously be increased in strength steadily from the bottom to the top. This could best be done by using a thick tube and drawing, turning, or grinding it down on the outside to a uniform taper, leaving the inside parallel to fit the handle bar pillar, but the usual practice is to have the tube uniform in thickness, with a liner fitted up the inside for a few inches at the bottom. This liner should be carefully tapered off at the top, so as to avoid a sudden change in the stiffness of the tube, as all such changes tend to encourage fracture.

Coming now to the fork sides. Each of these is really a beam fixed at one end and having a force applied at the other or free end tending to produce bending mainly in a "fore and aft" direction, though a certain amount of strength and stiffness is required sideways as well, to resist lateral deflection, when negotiating ruts and the like. For ordinary purposes there is no object in making these fork sides excessively stiff, as in a modern bicycle the energy expended by the rider in driving the machine is not transmitted through the front fork to the pedals, as it used to be on the old high bicycles. It follows, therefore, that a flexible fork can be used without interfering with the efficiency of the machine, and in the author's opinion a somewhat flexible fork is a distinct advantage for road work, as not only does it lessen the vibration in the handles, but by reducing the effects of shock at the point *A*, it lessens the liability to snap off short there. Hence, unless the author's experience is wrong, there can be no object in having an extremely rigid "triangulated" front fork after the manner of certain machines he has occasionally seen on the road of late. Apart from eccentricities of this sort, fork sides are invariably curved, the only question to be decided being the most appropriate section. Fig. 14 shows most of the sections that are in use.

The usual sections used are the elliptical, D, and fluted. The elliptical is by far the most common and answers its purpose fairly well, but with its usual dimensions, it is rather lacking in strength sideways. The D, or even a rectangle, would seem more suitable. The rectangular sections look ugly and out of keeping with the other parts of the machine, while the D section looks remarkably neat, and finishes off particularly nicely at the bottom end by the front wheel hub. Several leading makers have now been using D section forks for some years. Whatever section is used it is desirable to increase the strength of the fork from the bottom to the top by using tubes that have been drawn tapered, not only in external dimensions, but in gauge also. With regard to the fluted section, this seems to be distinctly inferior to the others mentioned above. A solid section having the same external dimensions as this fluted one, would compare well with the others, if they were also solid. When, however, the sections are hollow, the fluted form does not seem right.

In comparing the curved double tube fork with the fluted one, it will be noticed that they are practically the same design, but in one case there is a continuous web connecting the two "bulbs" and in the other there is not. The web prevents the bulbs from bending independently, and so increases their strength and stiffness considerably. When there is no web the tube on the inside of the curve, which under ordinary conditions is of course in compression, is liable to buckle, the result is that a *curved* fork side, consisting of two tubes unconnected except at the ends, is weaker and more flexible

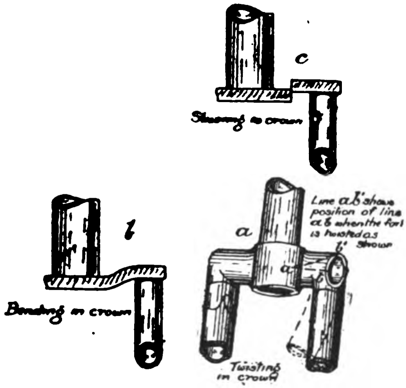


Fig. 17.

than would be inferred from the figures in the table of sections, these applying only to tubes which are straight between points of support, and connected together at frequent intervals. However, the strength and stiffness of a double tube fork can be increased, without adding to its weight, by spreading the tubes further apart at the top of the fork, and this is generally done when two tubes are used.

Connection of Fork Sides to Steering Tube. This connection is usually made just below the bottom of the head by means of what is known as the "crown" of the fork. As will be seen from Fig. 16, this "crown" is essentially a horizontal piece of metal, into the centre of which the steering tube is fixed and to the extremities of which the fork sides are attached. It will be evident that the force *R* tends to produce torsion in this horizontal piece, combined with a certain amount of upward bending. This latter is, however, very slight and need not be taken into account. There is also a tendency to shear. These three possibilities are shown in an exaggerated way in

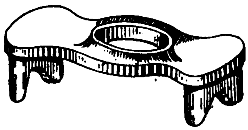


Fig. 18.

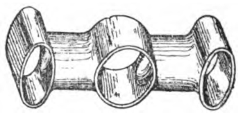


Fig. 19.

Fig. 17. Bearing in mind what was said in Chapter II. on the strength of different sections of material when subjected to torsion, it will be evident that a single flat plate, as Fig. 18, is entirely unsuitable, notwithstanding the fact that at one time it was very much used. A hollow cylindrical crown, as shown in Fig. 19, is a good design and is used to some extent. The Fig. shows one worked out of a tube, but it may be made from a steel stamping bored through from end to end to bring it to the proper section, another hole being bored vertically through the central boss to take the steering pillar; this style of crown is

used on the "Raleigh" bicycle, and is adopted in Design "*G*," Plate V.

The usual design, however, is to retain the original flat plate of Fig. 18 and put another parallel one about an inch lower down, the steering tube passing through this lower plate as shown in Fig. 20. A still better design is that shown in Fig. 21, which, while retaining the main features of the ordinary two plate crown, gives a long surface of contact for both the steering tube and fork sides, thereby enabling the brazing to get a better hold. In some cases these crowns are cut out of the solid, the two

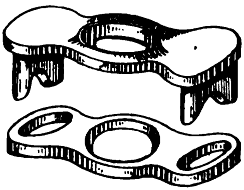


Fig. 20.

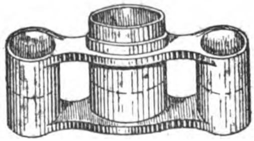


Fig. 21.

plates and the connecting bosses being all in one piece, but an easier method is to stamp two identical crown plates with three short bosses, so that together they make up the complete crown, as indicated by the dotted line. This latter method enables the central boss encircling the steering tube to be turned on the outside in a lathe, a good deal of the inner surface of the plates being machined up at the same time.

Let us now consider the merits of the two plate crown. If the two plates are equally strong the force *R* tends to produce twisting about a horizontal axis situated half-way between them. We have then, *R multiplied by the leverage* x is equal to *the resistance of each plate multiplied by its distance from this horizontal axis*, which is the same thing as the resistance of one plate multiplied by the distance between the centres of the two plates.

Without investigating the exact nature of the resistance offered by each plate, or in other words, the character of the stresses in the plate, it will be evident from the foregoing that the farther they are apart the less is the resistance expected of them. Hence, if no inconvenience arises in any other direction, the farther apart they are the better. Some makers use three crown plates, but this is not a very rational proceeding as the middle plate, containing as it does the axis around which the twisting takes place, is in precisely the same condition as a single flat plate subjected to twisting, a condition, it may be remarked, of very slight utility. If a third plate must be introduced, let it be split in half and each half added to the adjoining plate. It would then be doing more good, and the next time a crown has to be made, such a roundabout process of strengthening it would probably not be perpetrated. If it is desired to put the two crown plates very far apart, the best plan is to put one at the top of the head and the other at the bottom, in the manner first introduced in the old "Duplex Excelsior" some quarter of a century or so ago. This makes an extremely strong arrangement, and as it involves carrying a continuation of the fork sides right up to the top of the head, it gives virtually three steering pillars, thus greatly reducing the likelihood of a sudden breakage in this quarter, which is a most dangerous form of accident. Whether it is worth while to adopt such extreme measures in an ordinary machine is somewhat

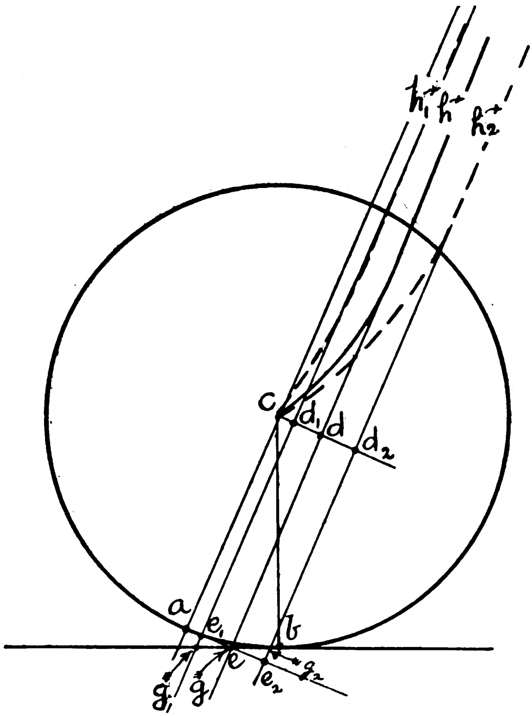


Fig. 22.

questionable, but there is much to be said in favour of this design for tandems.

Rake of Steering Pillar and Curve of Fork. The inclination or rake of the steering pillar may be varied very considerably without interfering with the steering, provided the fork is appropriately shaped. If, however, too great a rake is adopted, the average thrust on the ball bearings in the head is in a direction excessively inclined to the centre line of the head, causing uneven wear in the ball races, and the bending effects on the crown and steering pillar are also objectionably great. The most suitable angle can only be found by actual experience, it appears to be about twenty-three degrees to the vertical.

With regard to the curve of the fork, it will be seen on examining Fig. 22, that the centre of the wheel may be regarded as the extremity of an arm *cd* projecting at right angles to the axis *gh* of the head, and as the wheel turns this centre swings round in a plane also at right angles to *gh*. When the wheel is straight it always touches the ground at the point *b* which is vertically below *c*, and when it is swung round at right angles as shown in Fig. 23, it touches the ground at a point on its circumference marked *a* in Fig. 22, being the extremity of a radius drawn through *c* parallel to *gh*. As seen in Fig. 23, *a* will always appear to lie in the axis *gh*, for *gh* and *ac* coincide, as seen from this point of view. It will also be observed that this point *a* swings around the axis *gh* with a radius *ae*, in precisely the same way as the point *c* does with its equal radius *cd*. In Fig. 22 three different positions of the axis *gh* are represented, corresponding with three different fork curvatures. These are lettered g_1h_1, *gh* and g_2h_2. Let us take g_1h_1 first. On swinging the wheel round, the point *a* will appear to move along the line $a\ e_1$, and will be exactly behind e_1 when the wheel has swung through a right angle. Now, in this position the wheel will rest on the ground at the point e_1, which must consequently be lowered to the ground level. Hence with the axis in the position g_1h_1, turning the wheel lowers the front of the machine, and hence the weight on the front of the machine tends to slew the wheel round. Taking g_2h_2 next we find that e_2 will be the new point of contact with the ground, and the front of the machine must therefore be

Fig. 23.

raised on turning the wheel aside; and hence in this case the weight tends to keep the wheel straight. Taking, finally, *gh*, we find that *e* is already on the ground, and so the machine is neither lowered nor raised when the wheel is turned. This occurs when the axis *gh* cuts the ground at a point *g*, such that $gb = cd$. This represents about the right position for *g*, at any rate it should not be any further forward than this, and can be *a little* further back with advantage.

In addition to this lowering or raising of the front of the frame, there are two other actions involved in automatic steering. Imagine the axis *gh* to be an actual rod stuck in the ground at *g*. If we now attempt to turn the wheel, the point *b* must slide sideways over the road. What actually happens under ordinary conditions is the reverse of this, for the point *b* remains more or less stationary and the front of the machine is swung sideways, and it is this side swing, produced by the semi-unconscious action of the body and feet, that enables the machine to be steered without the hands. The wheel always tends to right itself, owing partly to the cause mentioned above when the distance *gb* is small, but mainly to the castor-like action which comes into play as soon as the machine is set in motion. This castor-like action increases with the distance *gb*, and also with the speed, as the backward drag on the tyre where it touches the road is greater when riding fast than when riding slowly; hence it is quite possible to steer without the hands many machines in which the point *g* is much too far forward, but only when riding decidedly fast; a well designed machine should steer automatically at a very moderate speed. It is also possible, on the other hand, to steer without the hands machines in which the points *g* and *b* coincide, the wheel then rights itself by the raising and lowering of the frame, there being no castor-like action. In this case the course of the machine is controlled by leaning the machine one way or the other after the manner of a hoop, the frame does not swing sideways as the wheel turns, and consequently the feet, which are ordinarily able to deflect the wheel in this way, have very little influence in the matter.

In considering the above remarks, it must be borne in mind that if the two wheels do not run in the same plane when travelling straight ahead, the steering will always be more or less erratic.

CHAPTER IV

FRAMES OF RACING BICYCLES, LADIES' BICYCLES AND TANDEMS

We have up to the present been dealing almost exclusively with the roadster bicycle for the male rider, but will now pass on to other types, though much that has already been said will be found to apply to all cases.

The Racing Bicycle. By this term is meant a bicycle built for attaining the maximum possible speed on a fairly smooth, level, and clean surface. On such a machine there is no need for splash-guards, foot rests, brake or gear-case, and the tyres are usually reduced in diameter from $1\frac{3}{4}''$ to $1\frac{1}{2}''$ or even $1\frac{1}{4}''$. Design "*H*," Plates III. and IV., has been prepared to comply with these conditions as far as possible. It will be noticed that the spoke flanges are $2\frac{1}{8}''$ apart, and their diameter is increased to $2\frac{1}{2}''$ to compensate to some extent for the reduction in width. The centre line of the chain is $1\frac{3}{8}''$ from the centre of the hub, and the distance across the crank faces is $4''$ only, with a perfectly symmetrical tread. The chain stays are of D section and the seat stays likewise; as when it becomes necessary to depart slightly from the simple circular section, this is about the best that can be adopted. The chain stays are brazed to a symmetrical stamped steel cross-head or bridge, the continuation from there to the bottom bracket being by means of two plain parallel tubes, $\frac{7}{8}''$ diameter. This enables a chain wheel of any size to be used without altering the angles of the connections in this quarter, all that is required is to lengthen these two $\frac{7}{8}''$ tubes.

In the roadster design, as very slight variations are needed by people who buy this class of machine, probably two patterns of bottom bracket, bridge, etc., would be sufficient, but the case of racing machines is different. They are not built for mere utility, and one has to be prepared to fit chain wheels of almost any size that will clear the ground.

The back corner, chain-adjustment, and hub in Design "*H*" are borrowed from the "Osmond" bicycle, though the dimensions and sundry minor details are altered. The hub will be dealt with in the chapter on ball bearings, and the back corner and chain-adjustment were described in Chapter II. The "Osmond" design is not essential to this machine, a corner piece similar to that used on the roadster, but lighter and adapted to the D-shaped stays, could be used here, in combination with the ordinary type of hub. It will be noticed that the seat stays are perfectly straight all the way up, clearing the tyre by a quarter of an inch, and coming conveniently near together at the top to connect to the corner under the saddle in the usual way.

The other parts of the racer frame are similar to the roadster, except that everything is reduced in weight as far as possible, the thinnest of tubes being used and the lugs made as small and light as circumstances will permit. There are differences in the bearings, pedals, handle bars, etc., which will be dealt with in the chapters dealing with these subjects.

There remains one entirely original design of frame worthy of special mention, namely, that introduced by

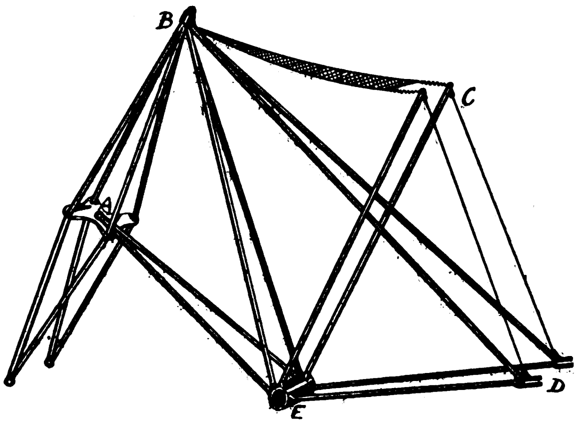


Fig. 24.

Mr. Pedersen. The construction of this frame is clearly shown in Fig. 24. It consists almost entirely of small tubes of very light gauge, no less than eight of these converging on to the bottom bracket. The chief element in the frame is the truss *B E D*, the weight on both the pedals and saddle being carried entirely by the bottom bracket, and transmitted from it to the centre of the back wheel and top of the head by this truss.

The lower end of the head is stayed to the bottom bracket quite independently by the two tubes shown. These prevent the fork from being pushed under the frame or bent out forwards, they being in compression in the first case; and tension in the second. There is no head in the ordinary sense of the term, the only connection between *A* and *B* being by means of the triangulated front fork itself.

The saddle consists of a sort of hammock slung from *B* to *C* and is of course in tension, the rear end being connected to the top extremities of a pair of tubular struts that run direct to the bottom bracket, these top extremities being prevented from coming forward by two steel wires strained back to the centre of the back wheel. This frame is extraordinarily stiff about the bottom bracket, and machines have been constructed on this principle by Mr. Pedersen which weigh as little as 14 lbs.

Ladies' Bicycle Frames. Apart from details, such as dress-guards, etc., the rear portion, *C E D*, of a lady's frame need not be any different from that of the ordinary roadster already described. A change is, however, necessary in the front portion, as the top strut *B C* is no longer permissible with the ordinary costume, and mounting and dismounting from behind is also out of the question. A lady has to be able to get on and off sideways, passing one foot across the frame a few inches above the bottom bracket, hence, all must be clear in that quarter.

One of the most obvious designs is to remove the top strut *B C* in Fig. 4, page 5, into the position *A G*, shown by the dotted lines. This of course weakens the frame, as the strut is now subjected to a greater thrust, and the diagonal *C E* is subjected to bending by the application of this thrust at the point *G*. Still, if these two tubes are made somewhat stronger, there is nothing very much amiss with the frame. The best way to strengthen the diagonal is to put a liner on the outside of it from the bottom to a point about six inches above *G*. The strut *A G* must be stronger throughout, if this frame is to be made capable of carrying the same weight as the ordinary

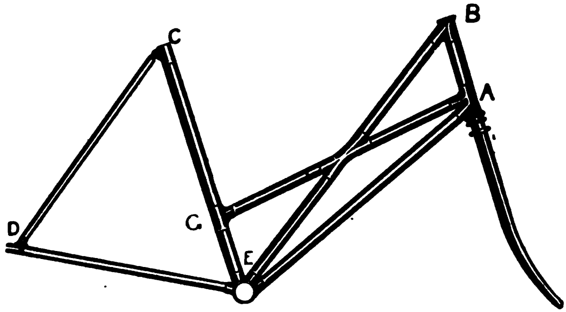


Fig. 25.

top strut frame. It need scarcely be pointed out that the defects in this design are immensely less than those in the designs of the majority of machines in use. The fact is, the front part of most ladies' bicycles is, when viewed from an engineer's standpoint, a fearful and terrible thing to contemplate, and if it were not for the comparatively gentle treatment they receive from their fair riders, many of them would get sadly distorted, if not positively broken. The author fears that the riders themselves are as much responsible for this state of things as the makers, as owing to the absence of "graceful undulations," they so often

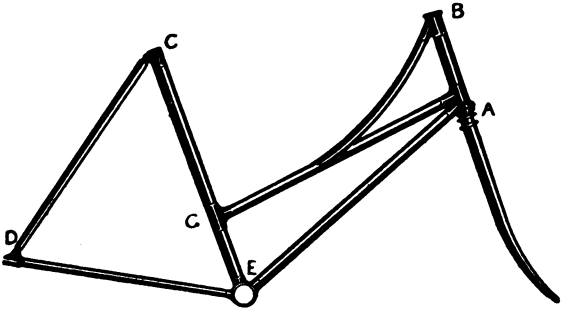


Fig. 26.

consider a mechanical design hideous, and that is fatal to the sale of machines so designed.

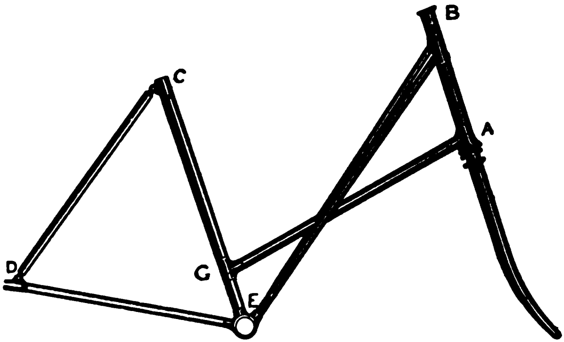


Fig. 27.

To return to Fig. 4, the author is not aware if any machine is constructed precisely like this, but the

"Raleigh," Fig. 25, is very similar, the only difference being that the member *B E* is a single tube crossing the tube *A G* through a special connecting piece. The "Osmond," Fig. 26, is also not greatly different, but the member *B E* stops short at the tube *A G* and is made curved with a spirit of true gallantry.

The "Elswick," Fig. 27, is also very like Fig. 4, but the member *A E* is entirely omitted. The extreme

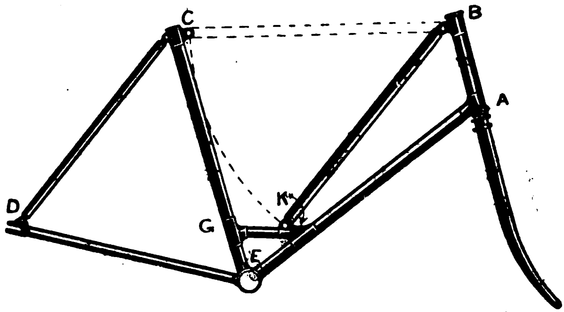


Fig. 28.

elegance and beautiful finish of these machines appear to have enabled the fair sex to overlook the absence of curves.

Fig. 28 represents another form of straight line frame occasionally used. The weak part of this is at the point *K*, as it is subjected to a bending that is by no means insignificant. As shown by the dotted line, this frame can easily be made convertible, which is often a convenience.

Fig. 29 is practically the same frame, but the parts *B K* and *K G* are curved.

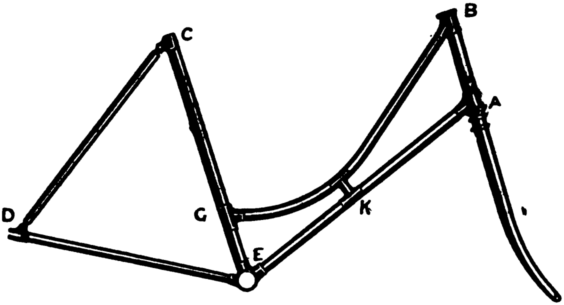


Fig. 29.

Fig. 30 is the curved frame of an American machine, the two tubes being braced together at intervals and

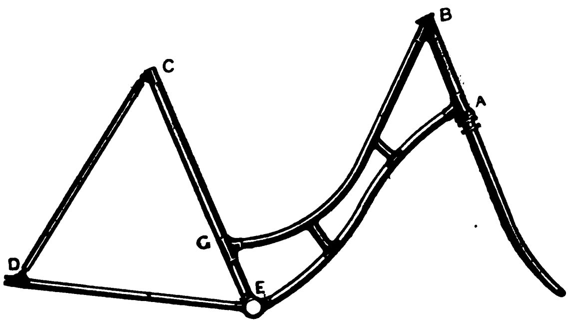


Fig. 30.

kept at some distance apart, both good features when a curved frame has to be used.

Fig. 31 merely shows how much can be done by good

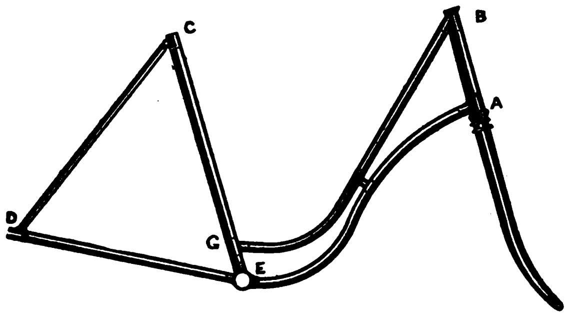


Fig. 31.

work and material. This design is used by a very well-known maker and the machines are popular, notwith-

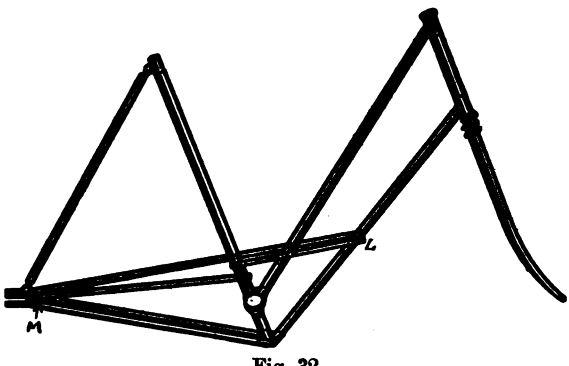


Fig. 32.

standing the entire disregard for all mechanical principles exhibited in the shape of the frame.

Fig. 32 is an entirely original design by Mr. C. W.

Brown, which is unusually stiff for a lady's machine. It is, however, somewhat complicated, and it appears to be impossible to get the bracing tube *L M* on the driving side straight through. It stops short at the diagonal and starts afresh lower down, which seems a pity. The frame relies mainly on the joints, of which there are a great many, for its strength and stiffness, as it is not a triangulated frame, in the technical sense of the term.

Strength for strength ladies' machines must necessarily be heavier than men's, but, as a rule, there is no need for

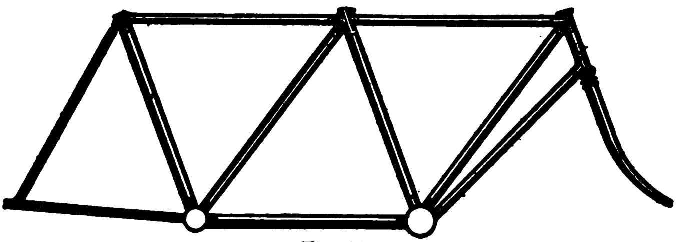


Fig. 33.

them to be as strong, and consequently the difference in the weight of ordinary roadsters of each type is not serious.

Frames of Tandems. Dealing first with tandems intended for men only, we have two alternative designs represented in Figs. 33 and 34. Fig. 33 is a pure triangulated design, while Fig 34 is a mixed design that has resulted from considerations of expediency. The fact is, it can be built any height without altering the angles of any of the corner pieces, except the ends of the seat stays, which are easily dealt with. The two parallel top struts increase the strength of the frame sideways, especially if the lower tube is made continuous right through. On the whole, in the author's opinion, there is not much to choose between these two designs, and he confesses to a slight leaning towards Fig. 34, notwithstanding its mixed character and the bending stresses in the upper corners and back diagonal.

However, the special points of interest in tandem frames are common to both designs. They are, the connection between the two bottom brackets, and the design of the fork and crown that it is desirable to use,

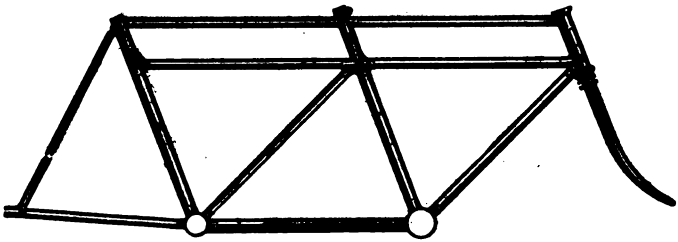


Fig. 34.

in view of the much greater weight to be carried by these latter parts.

Taking the connection between the two bottom brackets first. In some machines this consists of two parallel tubes about $\frac{7}{8}''$ diameter. They are usually placed in the same horizontal plane, though occasionally they are to be found one above the other. In other machines a single tube of very large diameter does duty here. Let us consider the merits of the three arrangements. We have practically the same problem here, as we had when considering the connection between the ordinary bottom bracket of the single machine and back hub; that is, we have side bending combined with twisting as shown by Fig. 3, page 4. Two parallel tubes, one above the other, are badly suited for resisting either of these. When placed side by side, they are no better for resisting twisting, though they are decidedly better able to resist side bending. However, a pair of parallel tubes, connected together at their ends only, are not well adapted to resist bending except when they are very short, as such a parallelogram can be deflected sideways to a considerable extent, without offering any very great resistance.

To overcome this weakness, the two tubes should be braced together by diagonal struts or by a continuous web, as in a fluted tube. This prevents the diagonals of the parallelogram from altering in length appreciably, and converts our two tubes into a properly constituted beam. But even now it is not a good structure for resisting twisting, and hence we find that, all things considered, a single tube 2″ in diameter is a more satisfactory thing than two ⅞″ tubes with a space of about 1″ between them, even though the gauge of the larger tube may be considerably less than that of the smaller ones.

Coming now to front fork and crown, we find that these have to carry the greater part of the weight of the front rider, as well as a small fraction of the weight of the back one. Hence, they must be constructed in a much more substantial manner than those of a single machine, though no new principle has to be introduced into their design. The plates of the crown should be kept about two inches apart and made somewhat stouter, the fork sides also must be made from a larger tube of slightly stouter gauge. A better plan is to use a triple head as in the old "Excelsior" and the modern "Referee," the fork sides being continued right up to the top of the head, the top crown plate being placed there to receive them. In this case, the fork sides should increase steadily in strength from the centre of the front wheel to the lower crown plate, decreasing again towards the upper one.

The only other special feature about an ordinary tandem frame is the eccentric bottom bracket for adjusting the front chain. This has already been dealt with on page 24.

We will now pass on to tandems intended to carry a lady on one of the saddles.

There are two distinct types, namely—

1. Those intended to carry the lady on the front seat, and—

2. Those intended to carry her on the rear seat.

Before dealing with these in detail it might be as well to say a few words on the merits of each arrangement.

The advantages of the first plan are—

a. Mounting and dismounting are easier, and the man can slip off in an emergency and avoid a disaster much more readily when he is riding behind than when he is in front. Again, if the road is blocked, he can slip off and manipulate the machine past the obstacle, and get on again, without in the least disturbing his companion, who may, indeed, be quite unconscious of what he is doing.

b. Owing to the above reasons, combined with the fact that the front rider is always visible to the rear rider, this type of machine is particularly well adapted for taking children and novices for rides. The author, who has had a machine of this type for a good many years, takes all sorts of people out on it, in fact at the outset, his wife went straight away for a ride of some considerable distance on it, without having ridden a bicycle of any kind before.

c. The coupled steering is a convenience at times, as the steering can be done by either rider, though it is usual for the rear rider to do it all, the front one merely "acquiescing," so to speak. The author has never found the least difficulty on this score, with any one in front who could ride a bicycle at all.

The disadvantages of this type are—

a. If the front rider is tall, has a large hat, or is otherwise difficult to see over or round, steering from behind is decidedly awkward. In fact, so much so is this the case, that unless a man is a good six inches taller than his wife, or other usual companion, this type of machine is a mistake.

b. However well the coupling rods are arranged, there is always a certain amount of spring between the rear handle bar and the wheel, which makes steering a trifle less easy than is the case when steering from the front seat, and the coupling rods themselves constitute also an additional complication, which requires a certain amount of attention and oil.

Coming now to the second plan, its advantages are—

a. Simpler and better steering, with a clear view.

b. One's wife may be any size, and may wear any kind of hat she likes, without causing one any inconvenience.

c. One catches the bulk of the flies in one's own eyes, and so saves those of one's wife. The same applies to the wind, but the eyes are not the only part involved.

Its disadvantages are—

a. Awkwardness in mounting and dismounting, though this may be greatly reduced by having a frame, the front

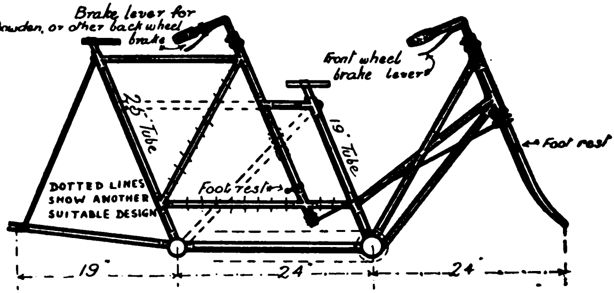


Fig. 35.

part of which is slightly dropped, so that the foot can be got over it more easily.

b. A lady does not look so well, or is thought not to look so well, when riding behind.

Returning now to the design of the frames. Fig. 35 shows a design for type No. 1, which practically explains itself. It will be noticed that the front part is that already described as being used on the "Raleigh" lady's bicycle. It comes a little high, but it must be remembered that this type of machine is always held for the lady to mount or dismount, and she is able therefore to do so at her leisure. The rear part of the frame is high, while the front seat is comparatively low, for, as already pointed out, the rear rider ought to be considerably taller than the front one if this style of tandem be adopted. The coupling rods consist of two steel wires $\frac{1}{4}''$ diameter, the end connections being plain $\frac{1}{4}''$ pins only. At first sight it might be expected that these would get worn and shaky, but as the wires are always kept tight by means of right and left hand screw couplers and check nuts, any wear that takes

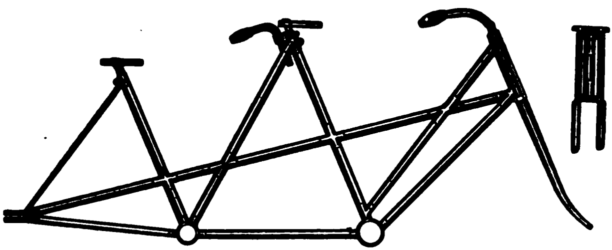


Fig. 36.

place does not make itself apparent. The steel pins are very easily and cheaply renewed when it really becomes necessary.

Turning now to Fig. 36, we find a design for a tandem of the second type, in point of fact the "Referee" tandem. In the author's opinion this is the best type of frame made, combining as it does a good mechanical design with a front part sufficiently low to enable a man to get his foot over it comparatively easily, while all is clear behind for the lady. This machine has also the triple head referred to on page 66, and so is quite sound in that somewhat vital quarter. The "Raleigh" tandem, apart from the head, is also built according to this design.

The author cannot leave this subject without making a few general remarks on the merits of tandems for married couples. As a rule a man is a stronger rider than his wife, and if they ride together on single machines, he either rides at a pace that gives him no exercise, or he tires his wife by taking her along faster than she can really manage comfortably. Towing is one way out of the difficulty, but is not a success as a regular practice, though it may be useful in an emergency. The true solution is a tandem, which equalizes matters perfectly, and enables distances to be accomplished that would otherwise be quite impossible.

As to speed, there is no getting over the fact that most ladies ride very slowly, an average pace of anything like twelve miles an hour for any considerable distance being exceedingly rare. On a tandem the improvement in this respect is most marked, especially up and down hill. The lady can put her feet up, whenever there is the least suspicion of a down grade, as a tandem gathers speed downhill much more rapidly than a single machine, the resistance due to air and road friction in the tandem not being increased to anything like the extent that the weight is. One of the most striking things about a tandem is the way in which, when all riders have their feet up, it will sail past single machines downhill. It also has a very marked advantage when riding against the wind. In fact, in the author's opinion, a tandem is a grand institution in a household, though a somewhat costly one.

CHAPTER V

BALL BEARINGS

THE object of a ball bearing is to change the sliding friction, that ordinarily occurs between two surfaces moving in contact with one another, into rolling friction. The exact nature of rolling friction will be considered in greater detail when we are discussing tyres, as it then becomes a matter of greater importance. So far as bearings are concerned, the resistance due to pure rolling is very slight indeed, but in all practical forms of ball bearings there is a certain amount of sliding as well, as the balls rub against one another, owing to the fact that the points of contact of any two balls are always moving in opposite directions (see Fig. 37).

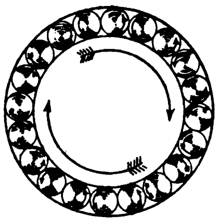


Fig. 37.

Theoretically a ball should have contact with any surface at a point only, and it should roll along a line. Practically it touches on a small surface and rolls along a strip of surface having an appreciable width, owing to the fact that no substance is hard enough to withstand the infinite intensity of pressure that would occur if the surface of contact were reduced to the theoretical point or line, of which the former has no dimensions at all and the latter length without breadth; neither is therefore possessed of surface, and so both are unable to withstand any pressure.

If a ball rolls upon a surface of appreciable width, more

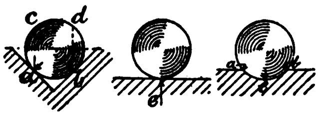


Fig. 38.

or less sliding must take place between it and that surface. For instance, suppose the ball in Fig. 38 to roll in a V-shaped groove and touch that groove at the two points *a* and *b*, then, in one revolution this ball would travel a distance equal to the circumference of a circle, which has *ac* or *bd* for its diameter. Suppose the ball, now, to roll on a plane surface, touching at the point *e* only. It will obviously travel further in one revolution than it did before, as it will roll on a larger circumference.

Finally, roll the ball in a groove that exactly fits it and so touches it at *a*, *b* and *e*. It is clear that the ball cannot roll at two different speeds at once, hence sliding, somewhere and somehow, has to take place, and this means friction and wear to a greater or less extent.

It will be quite obvious from the foregoing, that both the balls and the surfaces they roll upon must be as hard and smooth as possible, so that the surfaces of contact may be as small as possible.

As will be explained later, balls have to be run in grooves of some sort, and there was a time when it was thought better to run them in V grooves, rather than in grooves turned out to a radius. This has, however, been

Fig. 39.

Fig. 40.

proved by experience to be a mistake, the bearings wearing out much more rapidly than when the balls run on the ordinary curved surfaces. That this might have been expected will be obvious from the following—

Fig. 39 shows the situation in which a ball is placed in a V bearing, and Fig. 40 its situation in an ordinary bearing. It will be observed that, in the first case, it touches on three surfaces, and in the second on two, but all the parts of the two surfaces move at very nearly the same speed, as all points upon them are at very nearly the same distance from the axis (shown as a dotted line) about which the ball rotates. In the V groove, on the contrary, the two surfaces of contact *a* and *b* slope rapidly away from the axis, and consequently there is a considerable difference in the velocities of the different parts of the ball that are in contact with them. This accounts for the rapid wear that occurs in bearings of this type.

Ball bearings possess two other very important advantages. The first is that they can be adjusted with great exactness, so as to leave just the necessary amount of freedom without any appreciable shake. The second is that they are much less affected by dirt than the ordinary plain bearings used for most engineering purposes, as the dirt gets pushed away from the path of the balls and finds room for itself in the surrounding spaces.

Coming now to a more detailed consideration of the subject as applied to bicycles, we find two distinct kinds of bearings, namely, bearings in which the pressure is "axial," *i. e.* in a line with the spindle or axis of the bearing, and those in which the pressure is at right angles to the axis.

The head or steering socket of a bicycle is the only bearing that belongs to the first category, and in this the pressure is seldom really axial, though it is usually more or less so. As a rule, the axial pressure is the principal one, and the bearing is designed for that, in the first instance.

The balls are usually run in two grooved rings, precisely alike so far as the ball "races" are concerned. The grooves or races should be made with a radius distinctly larger than that of the ball, so that the ball runs on the bottom of the groove, without grinding too much against its sides. On the other hand, the radius must not be too large or the groove will not give the ball a sufficiently defined position, and there would be shake sideways in the bearing.

Plate V., design "*G*," shows a section of the head of a roadster bicycle. The distance between the two ball races depends on the height of the frame, and does not affect the design in other respects. The balls in the bottom row are $\frac{3}{16}''$ diameter, and run in grooves $\frac{75}{1000}''$ or 0·075″ deep, turned out to a radius $\frac{1}{100}''$ larger than that of the ball. The balls in the top row are $\frac{1}{8}''$ diameter, and run in grooves 0·05″ deep, turned out to a radius that practically fits the ball, there being just sufficient clearance to insure the ball bearing on the bottom of the groove.

This design does not appear to be quite in accordance with the foregoing theoretical considerations, but it must be remembered that the amount of turning that takes place in the head is comparatively slight, while there is a great deal of jarring, tending to produce side shake, and that is why the grooves so nearly fit the balls. If it were not for this jarring, tending to rattle the steering tube about inside the head in all sorts of directions, the top row of balls would have next to nothing to do. Having regard to these facts, it becomes a question whether a bearing designed primarily to take pressures at right angles to its axis, as in the case of the hubs and pedals to be presently described, would not be more suitable. The author has used both arrangements for many years, but has not come to any decision on their relative merits, except that he objects to the use of balls only $\frac{1}{8}''$ diameter in heads designed like hubs. Some makers use $\frac{1}{8}''$ balls for the bottom row in a head similar to that on Plate V., but these have a decided tendency to produce small indentations in the hardest ball races, which, though scarcely visible to the eye, are easily felt by running the point of a pencil quickly round the bottom of the groove. These indentations are due to the fact that the balls are nearly stationary when riding straight ahead, and each ball is constantly battered against a particular point in the groove by the jarring from the uneven surface of the road.

It will be noticed in Plate V., that the back of each grooved ring that fits into the steering socket is shaped so as to form part of a sphere, as indicated by the dotted circles. This enables the ring to automatically equalize the otherwise very varying and unevenly distributed pressure that is brought to bear upon the balls. The author made the acquaintance of this little device on a machine made by the Birmingham Small Arms Company and found it answer its purpose well.

The adjustment of bearings of this type is effected in a very simple way. The bottom pair of rings are pressed towards one another, and so naturally follow up any wear that there may be in the grooves. All that is then required, is to have some means of sliding the top ring of the upper pair down the steering tube, so as to cause it also to follow up the wear.

The usual plan, and the one selected for illustration here, is to fit the top ball race into the clip that is used for gripping the handle bar pillar. On slackening the bolt of this clip, it can be pushed down by means of a nut screwed on to the short piece of the steering tube that projects above it.

The usual method of gripping the handle bar pillar, is to slit the steering tube down for a few inches from the top. This is not entirely satisfactory, as the pinching in of the steering tube makes the nut at the top a slack fit on the thread of the screw. A better plan is that used by the Birmingham Small Arms Company, as shown in Plate V. Here the slit in the tube, instead of going right up to the top, is carried round for some distance, as shown, forming a sort of flap which is pinched in, the screwed part at the top remaining undisturbed.

Before going any further into this subject of ball bearings, it will be as well to settle on the material of which they should be made.

The author began his bicycling experiences in the year 1875, but did not ride sufficiently to test the quality of bearings until the summer of 1881. Since then he has been a most regular and persistent rider, and having worn out a very large number of cones, spindles, and cups, and done a good deal of experimenting on his own account, he has reached a somewhat dogmatic attitude of mind on this subject. This condition of mind is largely the result of the stolid obstinacy of the two leading makers, whose machines he rode about ten or twelve years ago, these machines being apparently the best and certainly the most expensive then made. The dogma is, that *tool steel carefully tempered*, so as to be quite unassailable by a smooth file, is the one and only substance that should be used for balls and the surfaces they roll upon; case-hardened material, whether iron or mild steel, being entirely unsuitable. Furthermore, if a capstan lathe or other automatic or semi-automatic machine tool, be it English or American, cannot make these particular parts out of tool steel, the fault lies in the machine tool and not in the material. The author had reason to hope that case-hardened bearings were permanently dead, but now is inclined to suspect that certain automatic tools, which are being somewhat largely introduced, may, through their inability to deal with hard steel, resurrect the case-hardened stuff again.

There is one other dogma about which, however, there is no question; namely, that all surfaces intended for balls to run upon should be trued up with a suitable emery grinder, or "lapping" machine, as it is called, after they have been tempered.

The author knows that bearings so constructed will run for years without exhibiting the least sign of wear or requiring any adjustment whatever. He also knows, that bearings which are not so constructed will wear into deep rough ruts in anything from a few hundred to a few, *very few*, thousand miles. There may be exceptions, but he has not met with them, and does not feel disposed to knowingly try any more experiments with case-hardened material, be the maker who he may.

It might be as well, for the benefit of readers unfamiliar with the properties of iron and steel, to explain that tool steel is a compound of iron with about 1% of carbon. It is at all times a comparatively hard substance, that cannot be cut very rapidly with any kind of tool, and it can be made intensely hard by a process known as "tempering," after which it can only be cut by means of a rapidly revolving wheel, made of emery or some similar substance. The tempering consists in cooling the metal suddenly from a high temperature, thereby making it "dead hard." It is then "let down" to the required "temper" by warming it up again, and watching the colour of the oxide that forms on the bright surface of the metal, this being an indication of the temperature. The warming up softens the steel and makes it less brittle, the process being stopped the instant the right "temper" has been reached, by cooling suddenly in water or oil. Oil cools the steel more slowly than water, giving a softer "temper." The colour of the oxide for a hard "temper" is pale straw, and this is what is required for bearings. The colour deepens as the temperature rises, becoming ultimately the dark blue or purple which one is familiar with on clock springs.

Mild steel, on the other hand, is, to all intents and purposes, the same thing as good iron. It cannot be hardened, it is tough and soft, and so can be cut easily and rapidly by a machine tool, the material peeling off in large shavings. In order to make this material more or less suitable for balls to run upon, it is case-hardened. The process consists in keeping the finished article at a red heat for some twenty-four to forty-eight hours, in contact with some substance rich in carbon, the air being carefully excluded. The result is that the surface for about $\frac{1}{16}''$ deep, becomes to some extent similar to tool steel and can be hardened. However, it does not seem to answer for ball bearings; though, when cleaned up true with an emery wheel, it is excellent for the wearing surfaces of railway axles and such like things. The balls appear to indent the surface and cause it to chip off, and when that process begins, the ball race is rapidly transformed from a smooth bright line to a rough uneven rut, which no amount of adjustment of cups or cones can possibly rectify. When this occurs, the sooner the worn part is replaced the better. Only a very small amount of adjustment need be allowed for in any ball bearing, for if it is made of really hard steel, it will never require more than a very minute amount of adjustment, and if it is not hard, or not made of good steel, it will inevitably wear so unevenly, and get so rough, that adjusting it becomes a farce.

Returning once more to the mechanical details of bearings, we will proceed to study those in which the pressure is applied in a direction at right angles to the axis around which the balls roll, in other words, hub, pedal, and crank spindle bearings.

All these bearings are constructed on the same principle. Into the body of the hub, pedal, or bottom bracket, there are fitted a pair of cup-shaped ball races, known as "cups," and onto the spindle are fitted a pair of "cones," though they are not really cones, for the sloping surface is curved. The balls run in the rounded corner of the "cup," which is turned out to a radius somewhat greater than that of the ball. They also run on the sloping surface of the cone, the point where each ball touches the cone being diametrically opposite its point of contact with the cup. Now, as the diameter of the ball, passing through its two points of contact, is inclined at something like 45° to the axis of the bearing, it requires two cups and two cones facing in opposite directions to constitute a complete bearing.

The bearing is adjusted by pushing the cones further into the cups, or the cups further on to the cones, and so causing the balls to run on larger diameters of the cones. This, however, is not essential, for the cups might be turned out to a large radius in the corner, so as to

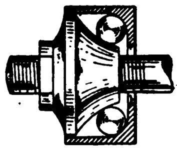


Fig. 41.

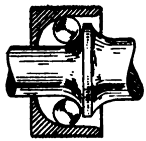


Fig. 42.

form hollow "cones," and the cones grooved so as to perform the functions of the cups. If this were done, the balls would always run on the same diameter of the cone (meaning the part on the spindle), and would be adjusted, for reduction of that diameter by wear, by being caused to run on a *smaller* diameter of the hollow "cup."

The first method spreads the balls further apart as they are adjusted, the second brings them in closer together. On the whole, the first is the better method, and is certainly the more usual. Fig. 41 shows the first method and Fig. 42 the second.

Fig. 43 shows a bearing in which the balls are run in plain concentric grooves. There would be a good deal to be said in favour of this design, if it were capable of concentric adjustment. No method, however, has been devised for accomplishing this satisfactorily, except by running the balls on three points as shown in Fig. 44. This, as already explained, should be avoided when possible, and although bearings of this type have served a useful purpose on the old ordinary bicycles, and on tricycles, we have no need for them here.

Returning now to the cup and cone bearing, there

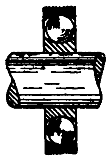


Fig. 43.

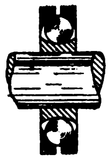


Fig. 44.

remains one general question to be settled before we discuss the details more precisely.

The question is, ought the cones (meaning the parts on the spindle) to face inwards towards the centre of the bearings, or outwards away from the centre? Though, as will be pointed out presently, there are certain features in the design of bearings that will slightly modify the answer to this question in special cases, the answer for all ordinary cases is clear and unmistakable, namely, *the cones should face inwards*, and for the following reasons—

(1) The pressure produced on the ball races by the pull of the chain is then less.

(2) The bending effect produced on the spindle by this pressure is less, indeed, in most cases nothing at all.

(3) The amount of wobble at the rim of the wheel, for a given amount of play in the bearing, is less.

Fig. 45 shows the truth of the first two of these facts. The upper part of the diagram shows inside-facing cones, and the lower part outside-facing. The line of action of the pull, P, of the chain is represented by the line p, which may be a little inside one row of balls or may not,

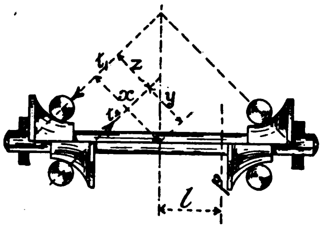


Fig. 45.

according to the pattern of hub. The direction and line of action of the thrusts, T and T_1, on the balls on the left-hand side are represented by the lines t_1 and t_2. The thrusts on the right-hand side, which we will call S and S_1, are of greater magnitude, but have similar lines of action.

We have then, from the conditions of equilibrium (or the principle of the lever, if that idea is more easily understood)—

$P \times l = (T + S)\, x$, for inward-facing cones,

and $P \times l = (T_1 + S_1)\, y$, for outward-facing cones.

when $l =$ leverage of P,

$x =$ leverage of T and S,

and $y =$ leverage of T_1 and S_1,

all measured from the centre of the bearing.

Now x is greater than y by the amount marked z, hence as

$$(T+S)x=(T_1+S_1)y \text{ and } x=y+z$$

we have $\frac{T+S}{T_1+S_1}=\frac{y}{y+z}$. which, if the reader will pardon the statement of such an elementary fact means that T_1+S_1 is greater than $T+S$.

Coming now to the bending of the spindle. If the lines of thrust pass into the supports of the spindle and not into the spindle itself between those supports, such thrust cannot produce bending. On the other hand, if these lines intersect the spindle between the points of support, the thrust does tend to produce bending.

Finally, with regard to the wobble in the wheel for a given amount of wear in the bearing. This is clearly shown in Fig. 46, which has been prepared from an actual model. The cups and cones are identical in both cases, and the amount of wear also. The extreme positions of the wheel are shown by dotted lines. This result is due to the fact that the hub swivels about a central point, and the relative movement of any cup with respect to its cone, is more nearly in the actual direction of the thrust, and consequently of the wear, with the inward-facing cone than with the outward-facing. In other words, the movement in the case of the inward-facing, tends to press the balls in a direction nearly normal to the curved surfaces

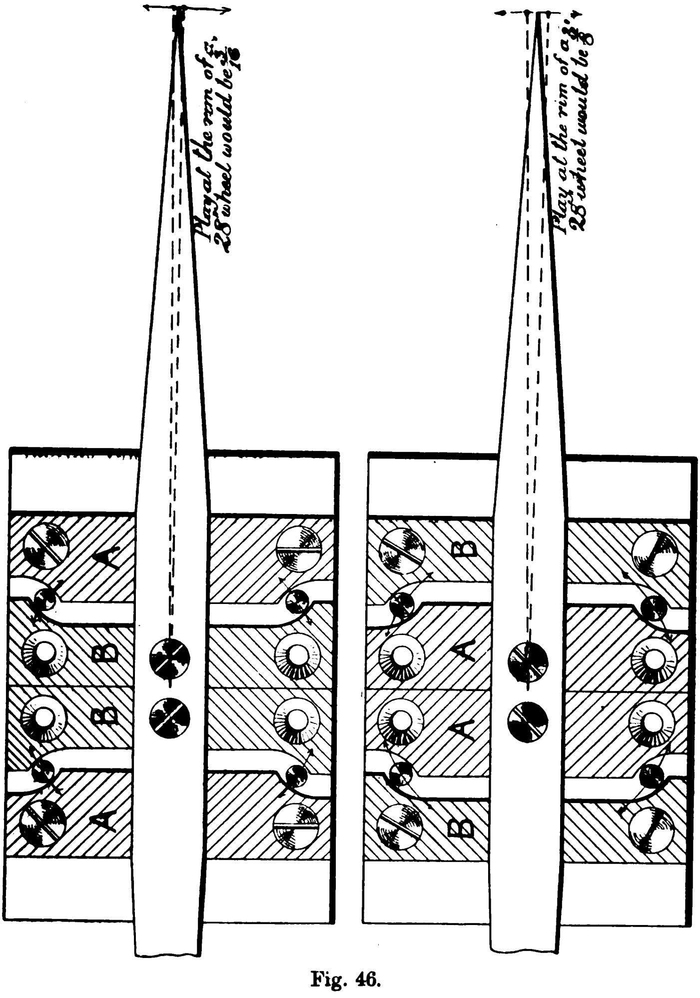

Play at the rim of
28" wheel would be 3/16"
Play at the rim of a
28" wheel would be 3/8"

Fig. 46.

they roll upon, whereas, in the case of the outward-facing cone, it tends to press them in a direction more nearly tangential to these surfaces.

It must not be supposed that these three objections to outward-facing cones are of any very serious practical importance, certainly not of sufficient importance to deter us from using such cones, if advantages are to be obtained by their use that have any considerable value.

Having now completed the discussion of the more general part of this subject, we can examine a few examples of hubs, crank spindle bearings, and pedals.

Hubs. Design "*G*," Plate II., shows, half in section, a hub with inward-facing cones. These cones are screwed on to a spindle $\frac{3}{8}''$ diameter with a fine right-hand thread. The cone on the right-hand side is screwed hard up against a shoulder on the spindle, and is never moved. The other cone is fixed in any position by means of an ordinary lock-nut. This lock-nut is usually outside the frame, and then also serves to hold the wheel in position. This, however, is by no means essential, there is nothing to prevent a thin lock-nut being put inside the frame for holding the cone in position only. If this were done, there would be no fear of shifting the cone accidentally, when taking the wheel out. This additional lock-nut is seldom fitted in hubs of this type, and perhaps is scarcely worth fitting, as, apart from serious repairs, there are only two things that usually involve taking out a wheel, namely, either to put on a new tyre, or to examine the bearing. In the first case, this nut would undoubtedly be a slight convenience, but in the second it would be precisely the opposite. It is not shown in Design "*G.*" The cups are merely pressed tightly into the recess in the body of the hub, there is no need for any other kind of fixing.

In all modern hubs of this kind, an oil-retaining cap or washer is fitted into the mouth of the hub so as to form a recess capable of holding an appreciable quantity of oil. This cap fits very closely round the cone, so as to exclude dust, etc. In many cases these caps are fixed in permanently, or are made solid with the cup. The author prefers to have them screwed in, as they can then be readily removed, and the bearing cleaned out in a most thorough manner with paraffin, without taking out the balls, which, however, can be seen quite sufficiently. These screwed caps, also, simplify the replacing of a worn cup, which is a convenience to people who do not sell their machines directly they show signs of depreciation.

So far as the author's experience goes, cups, cones, chains, brake blocks and tyres, are the only parts of a bicycle that wear out, and if these are replaced occasionally, there is no reason why a machine should not last for half a lifetime, if not for a whole one.

Some makers use felt washers, fitted, as a rule, into a recess behind the oil-retaining cap, the object being to keep out dust more effectually. They do not entirely prevent the oil from getting black, and they certainly add to the difficulty of washing out the bearing with paraffin. The author has tried these felt washers in many forms, but on the whole prefers to be without them, and to simply wash the bearings out occasionally with paraffin, relying on the closeness of the fitting to keep out the dust.

Adjustment of Hub Bearings having Inward-facing Cones. With bearings of this type, the method of adjustment is exceedingly simple and satisfactory. Two flats are cut on the cone on the left side, so as to enable it to be turned by means of a small thin spanner. The lock-nut is first slackened, and the cone screwed "home." The cone is then eased back until, whilst there is still no perceptible shake at the rim of the wheel, the bearing is quite free.

The freedom of a bearing should not be tested by spinning it round rapidly, that is a useful test to make sure that everything is clear about the chain, gear-case, etc., but is not sufficiently refined for testing the ball bearings. The correct method is to set the wheel gently in motion, and *observe how it stops.* It should not stop "dead," but swing backwards and forwards for some considerable time, stopping eventually with the valve (the heaviest part of the rim) at the bottom.

As previously pointed out, a really good bearing of this kind very seldom requires any adjustment at all, and should certainly run from 2000 to 3000 miles without developing any appreciable shake.

In a new machine a very small amount of adjustment may be required after the first hundred miles or so, particularly if the bearing surfaces have got any nickel on them, which, by the bye, they certainly ought not to have. After that, there should be no more adjusting done, or any nuts disturbed for months, under all ordinary conditions. The front hub is practically the same as the back one, but it has $\frac{3}{16}''$ balls instead of $\frac{1}{4}''$ ones, and there is of course no driving gear upon it. The spoke flange of a front hub should not come too close to the fork, as the peg for driving a cyclometer projects about $\frac{1}{8}''$ to $\frac{3}{16}''$ from the spokes, and it ought to clear the fork by $\frac{1}{16}''$ or so. There are machines made by well-known makers, in which things are so close here, that it is very difficult to get a cyclometer on at all.

Material of Hub Body. The body of a hub, whether front or back, is, now-a-days, usually turned out of a solid bar of mild steel, though some makers consider that they get better results from stampings. With modern machine tools, the process of forming the hub is a very rapid one, and the results are uniform and accurate. The only objection to mild steel is that it rusts, and nickel plating, unless it is really well done on copper, is but a poor method of preventing rust. It is true that, owing to the presence of oil about the bearings, the hubs are much less likely to rust than some parts of the machine, but, on the other hand, replating a hub means taking the wheel entirely to pieces and rebuilding it again. It would seem, therefore, that some of the special alloys that have been introduced lately for hub bodies, should receive encouragement, as the cleaning of a bicycle immediately after a wet ride is a horrid nuisance, and to be able to postpone the cleaning, without fear of rust, would be a great luxury.

Adjustment of Hub Bearings with Outward-Facing Cones. Turning now to the back hub shown in Design "*H*," Plate IV. This has outward-facing cones, and, as in most hubs of this kind, the adjustment is made by means of a movable cup, both cones being fixed at a definite distance apart.

In this particular design both cones are formed on a hard steel sleeve, through which the spindle passes, as on the "Osmond" bicycle. This plan, besides separating the hard and soft parts of the spindle into two pieces that can be independently treated, does away with the necessity for two lock-nuts for fixing the spindle in the frame.

In a front wheel hub of this pattern (not shown in drawings) the spindle merely has a head at one end, and a single nut at the other, the tightening of which presses both extremities of the fork tightly against the ends of the steel sleeve.

In the back hub the arrangement is slightly different, the lock-nut being on the sleeve inside the frame. By tightening this lock-nut the far end of the sleeve tightens against the frame at that end, whilst the lock-nut itself tightens against the frame at the near end, the nuts on the extremities of the spindle inside the tubes of the frame taking the pressure in both cases.

In some hubs the cones are turned on the spindle itself, which is made of carefully tempered steel, the middle and screwed ends being "let down" to a softer temper than the ball races. This is a rather delicate process, and is very apt to result in the ball races being soft, or, on the other hand, the body of the spindle being dangerously brittle. A much better plan is to screw two hard steel cones on to the spindle, the right-hand one being screwed with a right-hand thread tight against a shoulder, and the left-hand one screwed against a similar shoulder, but with a left-hand thread. This arrangement keeps the cones tight, as the rubbing of the balls tends to screw them up.

Now with regard to the methods of adjusting or fixing the cups. The one on the driving side may be simply screwed in tight against a shoulder with a left-hand thread, as shown in the drawing. It then tends to tighten itself up, and requires no check-nut, though in some cases one is fitted as an additional precaution. The other cup is screwed in with an ordinary right-hand thread, its position being adjusted by means of a peg spanner fitting into two holes in its outer surface, which has the appearance of a "disc." Hence the term "disc adjustment," sometimes used in connection with this type of hub. The only question is, how *to fix* the adjusting cup in a way that is both neat and effective?

The most obvious way of doing this is to let the cup protrude about $\frac{3}{16}''$ beyond the end of the hub body, and fit an ordinary thin lock-nut on to this protruding part. The objection to this method is that the tightening of the lock-nut is very apt to move the cup a little, and so disturb the adjustment; this lock-nut is also very large, and consequently requires a very large spanner to manipulate it.

It will be remembered that in the ordinary cone adjustment of the hub in Design "*G*," the frame comes between the lock-nut and the cone, and prevents the turning of the nut from moving the cone.

There are a large number of devices for locking a cup without risk of disturbing its adjustment, two of which will now be described.

On the "Elswick" bicycle, a loose ring slips over the protruding end of the cup, but cannot turn on it owing to two projections which fit into corresponding recesses in the cup (see Fig. 47). This loose ring has a large number of small holes drilled through it, any one of which can fit over a small peg projecting from the body of the hub. In this way the ring prevents the cup from turning. A locking ring screws on to the end of the cup, covering up the loose ring and holding it in position, at the same time

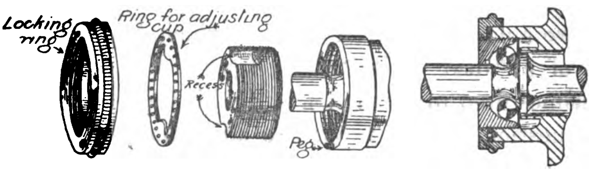


Fig. 47.

pressing the cup into its place, so making it tight. The locking ring is milled, and can be screwed on and off quickly with the fingers, a peg spanner being used to give it the last fraction of a turn when screwing on, and the first fraction when screwing off.

To adjust the bearing, this locking ring is screwed off, and the loose ring withdrawn from the peg. The cup is then adjusted, and the loose ring and locking ring put on again. This arrangement is very elaborate and is beautifully made, and, except that it involves a good deal of work in the process of manufacture, can scarcely be criticized from any point of view.

The other device is shown on the hub of the racing bicycle, Design "*H*," Plate IV. The end of the hub body has a number of slits cut down it, for a distance somewhat less than the length of the cup. This is important, as if the slits are carried too far, they allow the oil to run out of the bearing. These slits are about $\frac{5}{16}''$ apart, all round the hub. On to the outside cylindrical surface of this slit portion, a locking ring screws with a large buttress thread, that is, a thread with a vertical front and sloping back. On tightening this locking ring up against the shoulder, it tends to push itself up the sloping backs of the threads, and so presses in the slit cylinder and clamps it on to the cup inside it.

This method has been used a good deal on the "Osmond" bicycle, and other makers use a very similar arrangement with an ordinary screw thread cut upon a slightly conical surface, instead of a buttress thread. Either arrangement if well made holds the cup tightly, and the tightening of the locking ring does not in any way interfere with the position of the cup.

With regard to the general merits of cup-adjusting hubs, there are certain conveniences associated with the steel sleeve and spindle within it, that have already been pointed out, but apart from this, it is difficult to understand why manufacturers put themselves to the trouble and expense of making these hubs, for they all seem to find them more expensive than the ordinary style.

The advantage that the adjustment is not disturbed when a wheel is taken out, is, as has been already pointed out, not the exclusive property of this type of hub, or indeed more easily obtained on this type than on the other.

Cup-adjusting hubs do not lubricate the balls better, or keep out dust better than the other type, while they possess the following disadvantages.

Firstly, in order that the oil shall reach the balls, when the machine is upright, a very large quantity must be kept in the hub. This is very apt to drip from the lubricator, which is seldom oil-tight when shut, and when the machine is laid on its side on the grass for any length of time, this oil runs out and makes a mess.

If it is asked—"Who wants to lay a machine on the grass on its side?" a sufficient answer is that the author and all his cycling friends do. On moors and downs, on which are the jolliest places to sit about, one naturally lays a machine on its side, the only alternative being to prop it against an amiable sheep.

Secondly, these hubs usually, though not always, require large and inconvenient spanners, absurdly different, for instance, to the remarkably elegant and useful little articles that are supplied by the Birmingham Small Arms Company.

The other points in connection with hubs, such as spoke flanges, gear wheels, etc., will be dealt with in subsequent chapters.

Bottom Bracket Bearing. We will now pass on to the crank spindle bearing in the bottom bracket. These bearings are almost always made with outside-facing cones and cup adjustment, as they are simpler and more convenient in this form than in the other. A cone-adjusting crank spindle bearing involves a large lock-nut on the spindle just inside the left crank, where there is no room for such things in these days of narrow tread, and moreover, the cup-adjusting bearing serves its purpose so well here, that there seems to be no sufficient reason for returning to the other type.

In Design "*G*," Plate I., a section through a bottom bracket of the usual type is shown. The cup on the driving side is simply screwed in tight against a shoulder, which in the drawing takes the form of a flange on the cup with four notches in it to enable it to be tightened by means of a claw spanner. The other cup is screwed in and fixed in any position by some locking device. In Design "*G*" a slit lug is formed on the front of the bracket, into which a square-headed set-bolt is screwed, closing the slit end of the bracket on to the cup. If the slit is not taken beyond the end of the cup, where it would let dust into the bearing, this arrangement is very satisfactory, and involves only the smallest of spanners.

In Design "*H*," Plate III., a slightly different arrangement is shown. A small, specially shaped cotter-pin is fitted through a lug on the front of the bracket, so that a curved surface formed upon its side bears against the screw thread on the cup. The pin is drawn in by a small nut at the bottom. This arrangement is simple, and is found to be very satisfactory in practice, though it is open to the objection that it tends to squeeze the cup out of shape. This objection is more theoretical than practical, for the pressure required to hold the cup is very slight, and the cup being of very hard steel is not readily deformed. There is one point, however, of great importance with this arrangement, and that is that the cup must be a really good fit into the bracket. If there is any slackness in the thread, this device does not work well. These cotter-pins usually require a slight tap with a hammer to slacken them. In many cases a locking ring or nut screws on to the cup as in the cup-adjusting hub. The "Elswick" bicycle, for instance, has precisely the same arrangement on its bottom bracket as on its hub. So long as the lock-nut does not tend to turn the cup, when being tightened, and does not require a large awkward spanner to tighten it, there can be no objection to its use, indeed it is less likely to get damaged by mechanically uneducated persons, than small set bolts and cotter-pins, which often have to put up with the most barbarous treatment.

It will be noticed that in both Design "*G*" and Design "*H*," the bottom bracket is made as wide as circumstances will permit, so that the overhang of the cranks at each end shall be as small as possible. This is obviously most desirable, as it reduces the pressure on the balls, and the wobble of the spindle for a given amount of slackness. A firm, durable bearing for the crank spindle is a most important point in bicycle design.

In some cases the cups, instead of being screwed into the bracket itself, are screwed into a separate sleeve, which, in its turn, fits into the bracket. This prevents the oil from getting into the tubes of the frame, when the machine is turned upside down to repair a puncture, and it also prevents the balls from going astray in a similar way when putting the bearing together. This is a little refinement no doubt, though corks put into the tube ends do nearly as well.

Coming now to the spindles of these bearings, it will be found that large numbers of them are merely turned out of a bar of steel, tempered, and ground up true. If this is well done and the steel is good they wear well, and though somewhat brittle, they are not nearly so liable to snap as a hub spindle similarly treated, owing to their much greater thickness. A better plan is to screw on cones with right and left-hand threads, as described in connection with the hubs of similar design. This increases the diameter of the whole bearing by about $\frac{1}{8}''$, but it makes it more durable, and admits of the wearing parts being renewed very readily.

Another alternative is to adopt the American device shown in Design "*H.*" Here the cranks, instead of being fixed to the ends of the spindle by cotter-pins, have each a section of the spindle forged solid on to them. These two sections screw into a hard steel sleeve with right and left-hand threads. The extremity of the part connected to the driving-side crank is wedge-shaped, and fits into a corresponding V-shaped recess in the extremity of the other part, which has also a slit cut up it for some distance from the bottom of the V. When these two halves are screwed in, they wedge themselves into one another and into the sleeve, so that both cranks are bound to go round together, the sleeve also revolving with them. To screw the cranks on or off, it is necessary to prevent the sleeve from turning round. This is done by having a collar on it with a hole in it, a set-screw put through the bottom of the body of the bracket fitting into this hole. This fixes the sleeve, and enables the cranks to be screwed out by turning them round backwards.

This device supplies us with a hard steel sleeve for the balls to run on, and by doing away with the holes in the cranks for the cotter-pins, makes it possible to bring them in closer and reduce the overhang to a minimum.

With regard to the ordinary method of attaching cranks to the spindle by means of cotter-pins, it has often been a puzzle to the author that the public and manufacturers have been content to put up with such a clumsy device for so many years.

If cotter-pins are well fitted and properly cared for they do not get loose or give any trouble. If, however, one happens to meet with an accident and get a crank bent, so that it fouls the frame, that crank has to come off before the driving-wheel can revolve any more. Now, most cotter-pins have to be driven out by means of a hammer, and what is more, they are often extremely tight in. If this hammering process be conducted by the roadside, with any implement that may be available, and in the somewhat hot and irritable manner probable under such circumstances, that cotter-pin has a very poor time of it. One way or another cotter-pins *do*, very often, get ill-treated, and consequently work loose at all sorts of inconvenient times. There is a very simple remedy for all this, which the author has made use of for many years, and which any one is at liberty to copy (see Design "*G*," Plate I.).

Take out the cotter-pins and screw them down from the plain end to a point that comes about half-way through the crank. This screw, which is usually $\frac{3}{8}''$ diameter, should have a Whitworth thread of the ordinary form and pitch. There is a slight difficulty about cutting this thread, owing to the flat on the cotter-pin, which should of course be untouched by the dies. Ordinary English stocks and dies will not do it, but "Pratt and Whitney" dies will do it perfectly, it being only necessary to run the dies down once. If dies of this pattern are not available the thread must be cut in a lathe, or new cotter-pins obtained without flats, these being formed afterwards.

The only other thing required is a $\frac{3}{8}''$ nut to fit the largest spanner carried on the machine. This nut should be tied up in a corner of the tool-bag until wanted. To remove the cotter-pin, take off the small nut on the bottom end and screw the $\frac{3}{8}''$ nut on to the top end, which must, and nearly always does, project about $\frac{1}{4}''$. A good pull with the spanner and the cotter-pin begins to draw out, and continues to do so until it can be pulled out with the fingers. The author has fitted this device to all the machines he has had for a considerable number of years, and has found it a great convenience, though, curiously enough, he has never been able to get any maker to supply a machine so fitted.

Pedals. The only ball bearings that still remain to be dealt with are the pedals. These are nearly always made with inward-facing cones, the two cups being formed in the ends of a long sleeve that covers the spindle. The chief difficulty, however, is with the spindle and cones, and we consequently find a great many different designs in use.

The most usual plan is to turn one cone on the spindle itself, close up to the crank (see Design "*H*"), the other cone being screwed on to the outer end and fixed by means of a lock-nut. This method has one rather serious disadvantage, namely, that there is a difficulty about hardening the fixed cone, for if the spindle is made brittle at that point, it is very liable to snap off if the machine has a fall. The author has, nevertheless, ridden thousands of miles with specially made steel pedal spindles tempered very hard, and with the exception of one that was evidently cracked in tempering, he has never broken any, though cranks have been badly bent with these spindles in them. Many makers, however, seem afraid to harden these spindles much, and the result is that they wear out more rapidly than any other part of the machine. Fortunately they can be used when badly worn, without any very great inconvenience, and the result is that large numbers of pedals are in constant use that have long since ceased to run on the balls at all.

In making steel pedal spindles that are to be hardened at the crank end, it is important to countersink the hole in the crank a little, and to round out the inside corner on the spindle with a radius of about $\frac{1}{8}''$. It is also rather a good plan to fix these spindles into the cranks by means of small cotter-pins, in precisely the same way as the bracket spindle is fixed into the other end. This avoids cutting a screw on the end of the spindle, which, unless it is very carefully rounded at the bottom of the thread, is apt to produce cracks in tempering or afterwards. If a screw thread is used it should be fixed by slitting the end of the crank, and tightening the jaws thus made around the spindle by means of a ¼″ steel set bolt. This makes a satisfactory attachment, and does not produce the severe stress in the spindle that the old-fashioned large nut on the inner side of the crank did. When this large nut, that was formerly used, was tightened up—and it had to be very tight—it was doing all it could to pull the end of the spindle off.

Turning now to the type of spindle shown in Design "*G*," we find the fixed cone is at the outer end, while the loose one is at the crank end. There is no difficulty about hardening the extreme outer end, as the hardening shades off gradually into the comparatively soft body of the spindle, and there is little fear of its snapping off near the crank. There is also, of course, no difficulty about hardening the loose cone at the crank end. This loose cone serves a double purpose, being also a lock-nut to prevent the spindle screwing out of the crank. The spindle is screwed into the crank, by means of a screw-driver applied to a slot cut on its inside end, this brings the cone fairly tight up against the face of the crank, and a small fraction of a turn given to the cone by means of a spanner fixes everything. Care must be taken, that this fraction of a turn given to the cone does not unduly slacken the bearing, which should therefore have previously been made a shade too tight. The little trouble on this score is very slight, and certainly not sufficient to warrant the addition of an independent adjustment for the bearing, with additional lock-nuts, etc. It only remains to point out, that whatever type of spindle is used, either the cup at the crank end should be recessed out, or the end plate of the pedal made so as to stop up the mouth of the bearing and enable it to hold a certain amount of oil, and that a cap must be screwed over the mouth of the cup at the outer end, so as to entirely block it up, and prevent oil escaping and making a mess, or dust getting in and doing much the same thing. These caps should be fairly substantial, so as not to get dinged in too readily.

Coming now to the external features of a pedal, we find two distinct varieties, known as rat-trap and rubber.

Rat-trap pedals are simpler, lighter and cheaper than rubber ones, and are usually used by people who regard extreme lightness as the most important consideration. The objection to them is that they are uncomfortable—particularly when very light shoes are used—and they damage the soles of the shoes very considerably. Rubber, on the other hand, is somewhat heavier, but gives a wide, comfortable foothold, which allows a shoe with a light and flexible sole to be used. One can get accustomed to almost anything, but if one has got into the habit of using very light shoes and rubber pedals, the change to rat-trap is distinctly unpleasant, especially towards the end of a long ride. Slipping of the feet on the pedals, which often bothers novices a good deal, is merely the result of inexperience in the management of the feet. With a properly roughed rat-trap pedal, or any ordinary rubber one, it is the rarest thing possible for an experienced rider to slip his feet.

The only difficulty about rubber pedals is that the bars have to be rather thick, in order to keep the feet off the central sleeve of the pedal. A good many makers have recently introduced pedals in which the rubber is very deep and thin, being clamped between two metal plates, instead of being slipped on to a central spindle. These rubbers wear out very quickly, and do not give the wide, comfortable bearing to the feet that is afforded by the ordinary square bar. The square bar also has the advantage of having four wearing surfaces instead of two, as it can be turned round when worn. On the whole a good square bar is the most serviceable thing for a machine that is much used.

Lubrication of Ball Bearings. The usual plan is to lubricate ball bearings with some thin oil, such as sperm. When this method is used only a small quantity should be introduced at a time, as if large quantities are carried about in the bearings, the machine must not be left lying on its side for any length of time, or most of the oil will run out. The great thing to be aimed at is to keep the bearing surfaces and the oil clean, and if that object is attained a very small quantity of oil is sufficient to keep the balls covered with the necessary film.

If black oil is seen oozing out of the bearing, that bearing should be well washed out with paraffin and then some more clean lubricating oil added. As a rule, if the oil in a bearing gets black quickly, it means that the bearing is soft, and the blackness is due to ground up steel or maybe iron. If this is suspected, the bearing should be taken entirely to pieces and the ball races examined. Sometimes the trouble may be due to a soft or broken ball, but this is not often the case, as the manufacture of balls seems to have reached a state of considerable perfection, and they seldom either break or wear. As a rule a wide, dull-grey coloured mark will be found on one of the ball races, probably on one part of the circumference only, instead of the clean bright line about $\frac{1}{32}''$ wide. On trial it will be found possible to file this grey mark with a smooth round file. This means that the cup or cone in question is a bad one, and the sooner it is replaced the better.

It is a little open to question whether such a lubricant as sperm oil is, after all, the right one. A bicycle is apt to be regarded as a *light high-speed* machine. From a certain point of view it is, though not in the technical sense of the expression. When travelling at twenty miles an hour the wheel bearings revolve at about 240 revolutions per minute, which, considering their small diameter, can certainly not be regarded as high speed, in these days when reciprocating electric light engines are run at from 500 to 600 revolutions per minute, and steam turbines at from 8000 to 12,000. The bearings of the crank spindle and pedals will, at the same speed, only turn from 90 to 100 times per minute, which gives a very slow movement at the small diameter of the ball race.

Again the pressures can hardly be regarded as light, when one remembers that at any instant about three-quarters of the rider's weight, and the pull of the chain are resisted by the reaction on the minute surfaces in contact with a few $\frac{1}{4}''$ balls. Now, the object of a lubricant is to interpose between the metal surfaces a film of oil that will not be squeezed out, and if this is accomplished the metal surfaces would never really touch.

Bearing these facts in mind, the author has tried as a lubricant for ball bearings, a heavy mineral oil, used for lubricating the inside of steam engine cylinders, and has obtained very satisfactory results with it. He ran one machine for some three or four years in this way, and then sold it to a friend, who continues to use the same lubricant. The machine has thus been in regular use since August 1894, and has travelled many thousand miles. The back wheel hub has a $\frac{5}{16}''$ spindle and eight $\frac{1}{4}''$ balls on each side, yet it has never been adjusted, or shown the least sign of wear. The same satisfactory results have been obtained in the back hub of a tandem made in the early part of 1896, which is still in the author's possession.

At first it might be supposed that this oil must add to the resistance in the machine to a considerable extent, as, owing to its viscosity, pedals filled with it will not spin with their usual freedom. However, pedals are not required to spin in actual work, and this resistance due to viscosity increases greatly with the speed, and is quite inappreciable at the ordinary rate at which a pedal turns. In fact, the author has been unable to discover, that using this oil slows a machine when running down hill, or at any other time, while it has many advantages, as he will proceed to point out.

In the first place the oil has no smell, and does not appear to evaporate or thicken even if left in the bearing for years. It does not run out of the bearing, and, to a large extent, it prevents mud and water from getting in. It enables a hub to be run for a whole year without attention, the usual oiling-up before a ride or during a very long one being entirely dispensed with.

The oil is injected into the bearings by means of a small brass syringe, such as used to be sent out with the repair outfit of Silvertown Tyres. This fills the bearing, and if the conical end of the syringe is pressed tightly against the lubricating hole, the oil can be made to ooze out at each end of the hub around the spindle. This is convenient, as if there is reason to suspect that the oil in the bearing has become dirty, the forcing in of a fresh supply pushes all the dirty oil out, and cleans the bearing without any need for disturbing a nut. The superfluous oil, which is remarkably inoffensive to the hands, is wiped off with a rag. This method of entirely filling the hubs is not essential and is a little inconvenient unless they are fitted with an internal oil guide or liner (see Design "*G*," Plate II.), as they hold such a very large quantity of oil; it is also, of course, necessary that the tubes entering the bottom bracket should be effectually plugged. This method of lubrication is especially suitable for the head, where the movement is slight, and any real or imaginary resistance due to viscosity of no consequence. It is advisable to have no oil hole anywhere near the bottom ball race, as it would allow dirt to get in, but a small hole should be drilled through the steering socket about half-way up. A sufficient quantity of oil can be forced in through this hole to keep the bottom row of balls lubricated for a very long time, and the top row is easily filled up through the ordinary hole.

This method of lubrication renders oil retaining caps and such like contrivances entirely unnecessary except on the outside ends of the pedals. The cones can be merely made to fit the mouths of the cups in the old-fashioned way.

The use of this thick oil will probably not commend itself to the general public, but those people who do use it seldom care to return to thin oil again. To run one's machine right through the season without ever using an oil-can or disturbing a nut has its advantages, particularly for ladies. There is also a ghost-like silence about the machine when it is running, which is pleasant.

CHAPTER VI

WHEELS

APART from the hub, a wheel consists of spokes, a rim, and a tyre. We will deal with these in the present chapter, beginning with the spokes.

Spokes. In old days the spokes were radial, being screwed into the hub-flange, and headed or nippled into the rim. This method was very unsatisfactory from the rider's point of view, as the spokes frequently broke off at the hub end, leaving the screwed portion buried in the hub-flange. To get this removed, a small hole had to be drilled down the centre of the broken piece of spoke, and a square tapered piece of steel, made out of a bradawl, driven into the hole. On turning this round the end of the spoke could usually be screwed out. The worst of it was, that most repairers were either not sufficiently patient or sufficiently skilful to perform this operation successfully, and consequently the hub-flange was often damaged so that a new spoke of the same size would not screw in properly. Fortunately the drilling out of spoke ends is now a thing of the past.

Another objection to the radial spoke was that it transmitted the force from the hub to the rim by shearing and bending, instead of by a direct pull. This is a serious drawback in a driving-wheel, though of no consequence in any other wheel, unless a powerful brake be used upon it. A simple running-wheel, that has to carry weight only, should, of course, have radial spokes, and consequently some makers continued to use radial spokes in their front wheels, after they had adopted tangent spokes in their driving-wheels. There was some sense in this arrangement, but the greater ease with which tangent spokes can be connected to the hub has gradually driven the radial

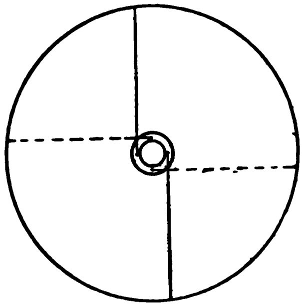


Fig. 48.

spoke out of the market, both wheels being now constructed in precisely the same way.

Tangent Wheels. The principle upon which these spokes are arranged is clearly shown in Fig. 48. If any attempt be made to turn the hub round while the rim is held firmly, a direct pull is produced either in the spokes drawn in full *or* in those shown dotted, according to the direction in which the force is applied. It is consequently necessary to have two sets of spokes in a wheel, one to resist turning in one direction, and the other to resist turning in the other. On tightening up these spokes, one set pulls against the other, and so enables the whole to be made quite taut.

Connection of Spokes to Hub. The spokes should be connected to the hub in such a way that if it be turned slightly without moving the rim, the spokes are not subjected to any bending. To accomplish this the spoke must be fixed by some kind of pivot having an axis at right angles to the spoke, and also approximately at right angles to the central plane of the wheel. The most perfect way of carrying out this idea would be to duplicate

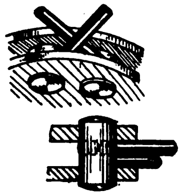


Fig. 49.

the hub flanges, the spokes going in between the flanges, and being fixed into a pin about $\frac{3}{16}''$ diameter, which passes through both flanges, as shown in Fig. 49. This enables the spoke to be made quite straight, and, the pin being in double-shear, is not liable to be tilted crooked in its hole. It is obvious that as the pin can turn in the flanges, the spoke cannot be bent. The nearest approach to this method, in actual use, is the arrangement adopted in the "New Rapid" bicycle. This is shown in Fig. 50*a*, which practically explains itself. This makes a very good wheel, though careless workmanship would be apt to bend the spokes, as shown in an exaggerated way in Fig. 50*b*.

The usual plan, however, is to make the pin and the spoke all in one, by bending the end of the spoke round, and passing it through the hub-flange, as in Fig. 51. A

Fig. 50*a*.

Fig. 50*b*.

head is formed at the end of the spoke to prevent its being dragged through the hole. At first sight this might seem to be an objectionable method, owing to the bend in the spoke. No doubt it is not theoretically perfect, but practically it is found to answer remarkably well, and gives

Fig. 51.

Fig. 52.

very little trouble in any way. So far as the author's experience goes, it is an exceedingly rare thing for a spoke to break off at the hub. On the "Elswick" bicycle the spoke-flange has a "bulb" round its circumference (see Fig. 52) to prevent the spokes bursting out through the edge of the flange, for this might occur if the spoke-holes were drilled too near the edge.

Connection of Spokes to Rim. In old days the spokes used to be headed inside the rim, and, as already mentioned, screwed into the hub. Now, however, as they are no longer screwed into the hub, they have to be screwed into the rim, or rather into special nipples fitted into the rim.

One of these nipples is shown in Fig. 53. They are, or should be, made of brass or gun-metal, the part that passes through the rim being round, and the projecting part square except just at the tip. The squared part is for the

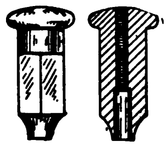


Fig. 53.

purpose of enabling the nipple to be turned by means of a small square notch in a spanner. The hole for the spoke is screwed, except for a certain distance near the tip; this is left plain to enable the screwed part of the spoke to be buried well out of sight. The underside of the head of the nipple should be spherical, so as to ensure its bearing properly on the washer inside the rim.

Coming now to the spokes themselves. The majority of them are made of plain steel wire of about 15 or 16 gauge, but the best ones are thicker at the two ends than in the middle. This is obviously desirable, as the spoke can be reduced in the middle part to the diameter at the bottom of the screw-thread without weakening it at all, but it is distinctly undesirable to reduce the bent part that passes through the hub-flange; hence both ends must be left thick, the middle portion being reduced. The process of manufacture should be one of thinning the middle portion, by drawing or otherwise, not of thickening the ends by "jumping them up," as this latter process reduces the strength of the steel, and does more harm than good.

There is one other point of interest in connection with spokes, namely, the manner in which they should cross one another.

Many makers pass the spokes that start on the outside of the hub-flange behind those that start on the inside. They are then all slightly bent, and press against one another where they cross. To prevent them from creaking or buzzing, they are wound at this crossing with fine wire and soldered.

Other makers keep the outside spokes outside right to the rim, and the inside spokes inside, though they still bind them together and solder them where they cross.

A third method is to keep the outside and inside spokes independent of one another altogether, as they naturally clear one another by about $\frac{1}{16}''$, and neither bind them nor solder them in any way. The spokes are thus quite straight. The author distinctly prefers the last of these three methods, and after years of experience has been quite unable to discover any advantage in the wiring and soldering process, and on the whole has had considerably less trouble with the unwired independent spokes. Hence now-a-days, when putting wheels together, he never thinks of wiring them, although such wheels are intended for his own use, and there is no question about time or trouble expended in making them as perfect as possible.

This is not a matter of much importance, but the unwired spokes are more easily replaced than the wired ones, if by any chance some one puts his foot through your wheel or in any other way breaks the spokes. It is also easier to tell when they are all at exactly the same tension, as the tone is a truer indication of their tightness than it is in the case of the wired and soldered ones. The wired spokes may have some subtle advantages, but the author has entirely failed to discover them or hear of them, and is therefore constrained to omit them.

Tyres. Coming now to the rims, we find that they are so intimately associated with the tyres, that they cannot very well be dealt with until the tyres themselves are understood. The tyres will therefore be taken first. Before doing so, however, it will be as well to consider in a general way the problem to be solved in making a good tyre.

Rolling Friction. When a wheel rolls upon a flat surface, it offers a resistance which is due to three causes. The first is that the tyre adheres more or less to the flat surface, and requires to be continually torn away from it.

Secondly, it may have to perform the function of a plough to some extent, digging a furrow as it goes along in some inelastic substance.

These two resistances are of a simple and obvious kind, painfully obvious at times, especially in an oolite district such as the Cotswolds.

The third source of resistance is more subtle, but is by far the most important from our present point of view.

As the tyre rolls along it is compressed to some extent, whatever it is made of. Work has to be done in producing this continuous compression where the tyre meets the road, and this is the cause of the resistance. If, however, the substance compressed be perfectly elastic, it will spring out again as the tyre leaves the road, giving a kind of kick out behind, which gives back the energy stored in it by the compression in front, and thus abolishes the resistance from this cause.

Now, air and all other gases are almost perfectly elastic, and recover themselves instantly on the removal of a load.

The recovery of compressed rubber, on the other hand, is comparatively sluggish, and is consequently too slow and too feeble to give good results on a bicycle. This is the reason why pneumatic tyres are so emphatically superior to solid or cushion tyres. Tempered steel is nearly as perfectly elastic as air, but a plain steel tyre would be much too harsh for use anywhere except on a railway, and the construction of spring wheels does not seem an encouraging pursuit. Even if they could be brought within the bounds of practical everyday cycling, they would never compete with pneumatic tyres, for the simple reason that the surfaces rolled upon are not flat, but full of small unevennesses, which a pneumatic tyre can absorb quietly and pleasantly in a manner that would puzzle any imaginable apparatus of steel. This brings us to another great merit in a pneumatic tyre.

The three resistances already referred to occur on a flat surface over which the wheel rolls without being continually moved up and down. When the surface is uneven, either the machine is lifted over every tiny obstacle, or the obstacle is engulfed by the tyre without raising the body of the machine at all. Now, the highly elastic qualities of a pneumatic tyre, combined with its great adaptability to the shape of the surface it rolls upon, enable it to smooth over all these lesser obstacles on the road with a minimum loss of energy, and also to very much reduce the shock produced by passing over large obstacles. These are virtues that are as beneficial to the machine as to its rider, and they have sent such things as broken spokes, loose nuts, and endless other troubles caused by the unmerciful vibration of a solid tyre into the limbo of the past. People may get a little bothered by punctures now-a-days, but these are less troublesome than the loose tyres we used to hear so much of formerly, and they are entirely let off the multitude of petty nuisances just referred to, unless they insist on complicating their machines with fanciful gears and contrivances.

With regard to the other points about a tyre, they may be stated thus:—

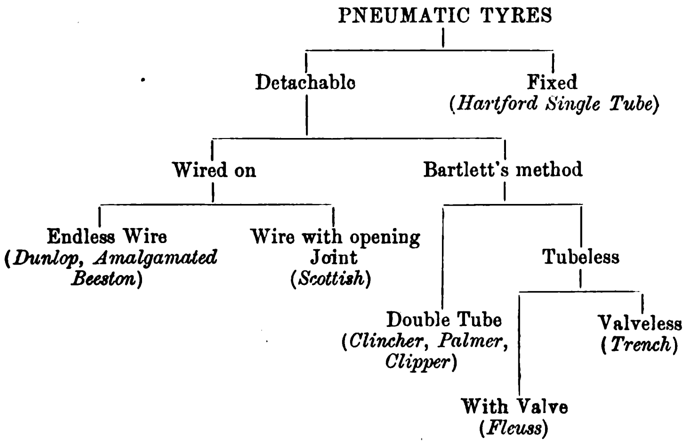
1. A pneumatic tyre should be composed of air, enclosed in a case as flexible and inextensible as possible, so that very little work can be wasted in bending it, or lost in transmission through it.

2. The case must also, of course, be really air-tight,

and resist the intrusion of sharp substances as much as possible.

3. The case must be durable, simple, and easily repaired. It is desirable also that it should get a good grip on a greasy road without being unsuitable for use with a brake.

The following is a classification of the chief kinds of tyres in actual use, the trade names being representative only.



In all cases the air is retained by a tube of what is, or ought to be, the very best quality of india-rubber. In the case of the tubeless tyre, the cover has a lapped joint all round, which, when closed, makes it virtually a tube.

The outer surface is also rubber, that being the only substance capable of protecting the inextensible part of the case from wear and moisture, and at the same time yielding sufficiently freely and continuously without cracking. Between the inner and outer rubber surfaces lies the inextensible fabric on which so much depends.

In order that this fabric shall be able to transmit force from the rim to the part of the tyre which touches the ground, without yielding much, the threads must lie in the directions indicated by Fig. 54, each thread finding its way from the tread to the rim in a direction capable of resisting a longitudinal pull.

In order also that the fabric shall be able to offer a reasonable resistance to sharp objects, its texture must be very close. In the "Amalgamated Beeston" tyre the special

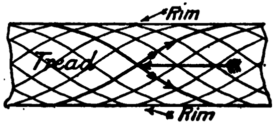


Fig. 54.

feature is a nearly impenetrable fabric, while in the "Palmer" it is the placing of the threads in the best possible direction.

A tyre to be used for racing on boards requires very little rubber outside the fabric, a thin strip on the tread being all that is usually used. In the case of roadsters, the durability and practical utility of the tyre depends very much on the quantity of rubber outside the fabric, and for most people who travel much on their machines, a good strong tyre has advantages that are well worth a small sacrifice in speed.

In comparing the relative merits of the different tyres mentioned in the general classification, the author feels that he is treading on somewhat uncertain ground, and has no desire to dogmatize, but nevertheless the subject must be dealt with clearly, as far as it is possible to do so.

Taking first, the question of detachable *versus* fixed tyres. These fixed or single tube tyres were at one time manufactured to a large extent in England. The Palmer tyre was originally a single tube tyre, and there were also the Silvertown, Boothroyd and others of lesser degree. Now, however, the Americans are the only important makers of single tube tyres, and such tyres are seldom found except upon their machines. In a single tube tyre, the outer rubber, inner rubber, and intermediate fabric are united together to form a tube, the interior of which is inaccessible. The author has had few opportunities of judging of the merits of the American tyres, but they are said to be very superior to the single tube tyres that used to be made in England, and for the sake of the manufacturers it is to be hoped that they are. The method of repairing them is as follows:—having found and abstracted the bent and rusty nail, or whatever it may be, a clean round hole is cut in the tyre by means of a special punch supplied with the repairing outfit. A rubber plug with a conical head is then pushed through this hole and fixed with solution, the pressure of the air forcing the base of the conical head against the surface around the inside of the hole. This is all very well for a nail, though the clean hole in the outer cover is apt to be a little troublesome even then, but what about a gash from a flint? Possibly there are no flint roads in America, but in England scraps of sharp flint are the worst enemies pneumatic tyres have. Occasionally they will cut clean through all at once, but more usually they make a gash, which soon becomes a source of weakness and eventually of a sudden collapse, unless it is repaired by a waterproof inextensible patch on the inside. Such a patch keeps the inner tube sound and protected, and, moreover, it can be put on in a few minutes by the roadside, and there is not the slightest fear of its coming off.

The tyre may be sent to the manufacturer's at any convenient time in the following winter, to have the cut permanently stopped by vulcanizing a piece in. With the Single Tube tyre an immediate journey to the manufacturer would be required, be it ever so inconvenient, as ordinary patching on the outside is but a very temporary and unreliable remedy.

It is undoubtedly the difficulty of repairing cuts, that has kept these tyres in the background in England, but their extreme simplicity, and the ease with which punctures can be located by merely turning the wheel round in some water and examining the outside of the tyre without undoing anything, should weigh heavily in their favour, and go far to balance the troubles due to an occasional cut, particularly with people who confine their riding to districts where sharp stones are seldom met with.

Passing on now to the question of wired tyres *versus* those attached by Bartlett's method. In Design "G" a section of a wired tyre and rim is shown, and in Design " H " a Bartlett tyre and rim. The author has two machines, one with one kind and the other with the other, and he regards this question as a matter of such small importance that he would be quite uninfluenced by it in buying another machine, provided the wired tyres had Westwood pattern rims, and a set of "One Minute" tyre levers were sent out with them. There was a time when the removal of a Dunlop tyre was a distinct nuisance, but Westwood rims and "One Minute" tyre levers have rendered their removal a matter of extreme simplicity.

The method is as follows:—having deflated the tyre and loosened the valve in the rim, the cover is pinched in to some extent all round so as to free it from the rim, to which it is apt to adhere a little. This allows the wires at one end of a diameter to draw into the smaller circumference in the centre of the rim, and so enables them to be pulled over the rounded edge of the rim at the other end of the same diameter.

To pull them over this rounded edge, a point near the valve should be selected, as the wires cannot be drawn into the centre of the rim here, and hence it would not do to begin opposite the valve. One of the levers is placed under the edge of the cover, and then pressed down and hooked round a spoke. The other two levers are used in precisely the same way, being placed some 3″ or so on each side of the first.

On depressing the third lever, the first will drop out and the tyre will be practically off. It only remains to put the fingers under the overhanging part of the cover and pull it off.

To put the cover on again does not as a rule require any instrument at all, the thumbs being sufficient. The tyre levers can, however, be used if turned over, but care must be taken not to nip the inner tube with them.

Comparing the above with the Bartlett method, we find that with tyres of this kind no instruments are needed or would be of any service. A part of the circumference of the cover is pushed back with the thumbs, so as to free it from the rim, and it is then drawn forward over the rim until a sufficient length is off to enable the inner tube to be got at. This is distinctly simpler than the corresponding operation with the wired tyre, though the advantage is not nearly so great as would be supposed from the simplicity of the description.

To put a Bartlett cover on again, the process is reversed. The cover is pushed over the edge of the rim with the thumbs and then tucked carefully in. This takes a little longer than with the wired tyre, and requires a little more care and attention, as it is quite easy to leave a small piece not properly tucked in. Should such a piece escape unnoticed, the inner tube will blow out and perhaps burst at that point, when the tyre is pumped up.

Such an accident is not likely to occur if the job is done at home, but may easily do so in the hurry of a roadside repair. On the other hand, when the wire of a wired tyre drops into its place, one knows that it is quite safe all round, and it will not come off on its own account.

So far as methods of attachment go, there remains only the wired tyre with the opening joint to be considered, the "Scottish" tyre being its representative.

Fig. 55 shows the arrangement. The wire is divided, and has at its extremities small blocks or nuts, screwed one with a right-hand and the other with a left-hand thread. These blocks are drawn together or moved apart by turning a right and left-handed coupling screw. This screw is prolonged so as to form a kind of handle. which is tucked away neatly just inside the rim. A few

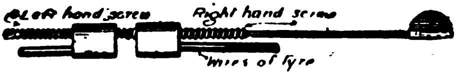


Fig. 55.

turns of this screw lengthen the wire sufficiently to enable it to be got over the rim quite easily with the fingers. It is equally easy to replace it.

The author finds that he can remove and replace these tyres more quickly and easily than any other kind he has had any experience of. No instruments of any kind are needed, the chance of nipping the inside tube is exceedingly small, and as no tucking in of the outer cover is required, it cannot be done imperfectly. On the whole this method seems to be an excellent one, the only trouble that suggests itself as a possibility being chafing of the fabric of the cover near its edge by the screwing tackle. The author has observed slight signs of this kind of thing, but not to an extent that can be regarded as of any consequence.

In conclusion it may be observed, that all three methods of attachment, in their present forms, are really so simple and convenient that no serious objection can be raised against any of them, except that the necessity for instruments in the case of the endless wired tyres may be regarded as a slight objection. It may be said that instruments are not really required, and no doubt it is possible to do without them, but this form of tyre is then

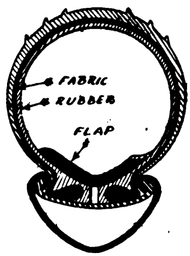


Fig. 56.

quite out of the running on account of the very distinctly greater trouble required for its removal.

It should be remarked that to remove a tyre from a bare rim in a shop, is quite a different thing to removing one from a completed wheel, where the hollow in the rim is half filled with nipple heads, washers, and the canvas that covers them.

Coming now to the question of Double Tube tyres *versus* Tubeless tyres (Fleuss, Fig. 56). The advantage of the tubeless tyre is this—punctures can be discovered by turning the wheel round in water and observing bubbles of air escaping *from the outside,* whereas in the double tube variety, if the puncture cannot be discovered by a simple inspection of the outer cover, the inner tube has to be taken out bodily and examined, which is a distinct nuisance. This nuisance may be to some extent abated by always having some water, with or without some harmless colouring matter in it, present inside the inner tube. This liquid escapes slightly if there is a puncture, and makes a mark on the inside of the outer cover and outer-side of the inner tube, by which the puncture may be discovered, without the trouble of inflating the inner tube and immersing it in water. This method, however, is not entirely reliable, as the liquid will sometimes fail to show through very minute holes, though air will still slowly escape. These very minute punctures are sometimes only discoverable the instant the tube is immersed in water, the mere wetting of the tube appearing to stop the flow of bubbles after the first two or three seconds.

The tubeless tyre introduces new possibilities of trouble in the form of a flap joint extending the whole way round the circumference. This must be kept perfectly clean and covered with a film of soft soap. If either of these things be neglected it becomes a source of leakage.

Tube tyres also have the advantage that they are extremely amenable to treatment by treacle, which is not the case with the tubeless variety. If about a wineglass full of golden syrup be injected into a somewhat aged and porous tyre the effect is really astonishing. The author has had a case of this kind directly under his notice for a considerable time. The tyre consists of an old Dunlop inner tube and a comparatively new "Scottish" outer cover. The inner tube was porous, and although no punctures were discoverable, it leaked down in three or four days and was a nuisance. It was treated to a dose of treacle about *eighteen months* ago and has not been pumped during the last nine months, being as tight as a drum still. The author has observed it carefully, and can discover no change whatever in the degree of tightness. This almost amounts to never pumping the tyre except after a puncture. There ought to be some serious disadvantage secreted somewhere, possibly there may be, but so long as it remains secreted it is of no consequence. There is one disadvantage apparent, namely, that it is necessary to clean all the treacle off the inner tube around a puncture, before a patch will stick, but this presents no serious difficulty. The author has heard rumours of treacle injuring the rubber, and so is at present not putting any into comparatively new tubes, but when treacle transforms an almost useless and certainly very troublesome tyre into an astonishingly good one for, let us say, twelve months only, any injury it may do to the rubber may well be overlooked.

We now come to the last type of tyre to be dealt with here—namely the tubeless and valveless "Trench" tyre (Fig. 57). Most of what has been said about the ordinary tubeless tyre applies to this variety also, but in this case the valve is dispensed with, which is a distinct step in the progress towards simplicity. Valves, as will be explained shortly, are all more or less a trouble, and their abolition would certainly be an advantage.

The method adopted in the "Trench" tyre is simply to use the flap joint of the tyre, not only as a valve for keeping the air in, but also as a valve for admitting it or releasing it. The pump is supplied with a long thin nozzle, which is inserted through a hole in the rim, which hole is at other times closed by a little milled headed screwed plug. If the nozzle is pushed in to full extent,

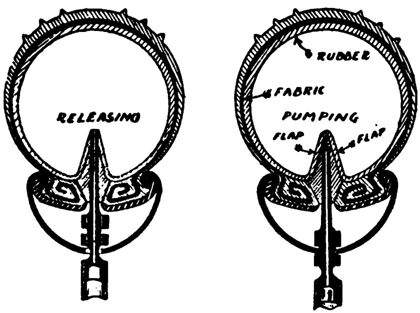


Fig. 57.

it passes the flaps and lets the air out; if, on the other hand, it is only pushed in a little way, the air can be pumped in, the flaps forming the valve. There is a notch on the shank of the nozzle to hold it in whichever position may be required.

If it is found by lengthened experience that the flap joint is a lasting success, a matter by no means certain at present, this type of tyre should become very popular.

Valves for Pneumatic Tyres. These are of two types, india-rubber sleeve valves and mechanical valves.

Fig. 58 shows the "Woods" valve, which is about the best of the india-rubber ones.

Air is pumped into a tube closed at one end, but having a small hole at the side. An india-rubber sleeve fits over the outside of the tube and covers the hole. When air is

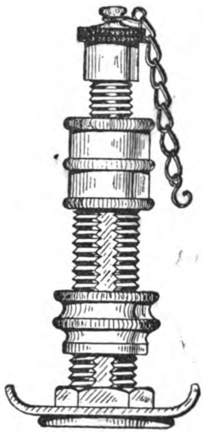


Fig. 58.

pumped in, it swells this sleeve and forces its way past it into the tyre, the automatic closing of the sleeve preventing the air from returning.

In this particular pattern of valve, the sleeve also fits over the cone which forms the releasing valve. The details are shown in the Fig. 59*a*. This valve is on the whole fairly satisfactory, but it possesses one serious fault. If it be fitted to the end of a pump and air be pumped through it out into open space, it will be found to require a very considerable amount of work, the actual amount depending largely on the condition of the rubber sleeve. All this work is waste of energy, and adds greatly to the labour of pumping tyres.

A second objection to this valve is that clumsy people will sometimes screw the releasing valve down so tightly,

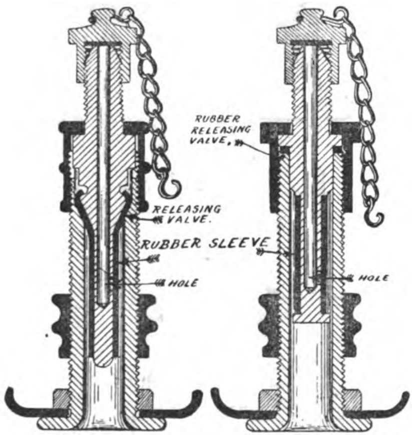


Fig. 59*a*. Fig. 59*b*.

that the sleeve gets damaged and consequently leaks. This can, however, hardly be regarded as a fault in the valve—clumsy people ought to learn or be a source of income to people who have learnt.

A third objection to this valve is that in time the rubber sleeve perishes and has to be renewed.

Fig. 59*b* is the Ross-Courtney valve, which is very similar, but has a separate flat valve seat for the releasing valve, with a small rubber washer on it. This may be regarded as an advantage by the above-mentioned clumsy folk, unless they happen to lose the small rubber washer. Owing to the way in which the sleeves are fitted on in these valves, they are a good deal harder to pump through than the other pattern. There may be people who like

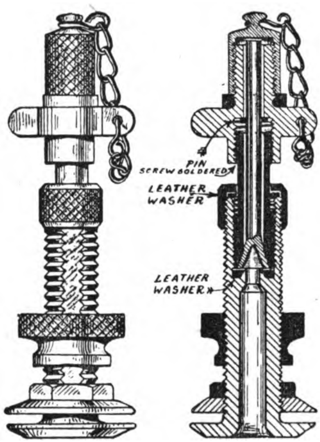


Fig. 60.

to get up a perspiration by pumping a tyre, but the author is not one of them.

The third valve illustrated is Lucas' (Fig. 60). This is a mechanical valve, and does not depend for its action on the inflation of india-rubber. It consists of a small screwed plug with a little metal "check" valve working in it. In the ordinary way this plug is screwed down against a small leather washer, the check valve being closed at the same time. To pump air in, the plug is screwed back by the wings on the spindle, until it comes against a second leather washer inside the cap of the valve. This prevents air from escaping past the screw thread. The little check valve can now open and air can be pumped in with very little effort, the valve itself offering scarcely any resistance at all. To release the air, the plug is screwed back as if air were going to be pumped in, and then the small projecting end of the spindle of the check valve is depressed with the finger-nail.

After pumping, the valve must of course be screwed up again by means of the wings. This valve is a little complicated, and the author has found that those people who will not understand things, but just learn them by heart, are apt to make a muddle of it. However, people who will not think, can generally work with their arms and do not mind perspiring, so they can drive away at the india-rubber valves. As a matter of fact, these Lucas valves are excellent things, and now-a-days the author will not have any other kind. One advantage of them is, that quite a short pump, that will go into an 8″ tool bag, is sufficient for pumping even tandem tyres. The additional trouble involved in unscrewing the winged spindle three or four turns before pumping and screwing up the same amount after pumping, is far more than compensated for by the reduction in the actual labour of pumping.[1]

[1] The Lucas valve for 1900 will have the plug screwed with a left-hand thread, so that screwing on the pump tends to open the valve, and screwing off tends to close it. This is a decided improvement,

It might be remarked that the small check valve is seldom quite air-tight until the plug is screwed down, hence it is advisable to screw this down before taking the pump off. The author has not found the leather washers to give any trouble, in fact most people would probably never become aware of their existence.

Non-Slipping Devices. Under certain conditions of the atmosphere roads made of almost any material, except flint, are apt to become greasy, rendering them difficult to ride upon, owing to the tendency the machine has to slip sideways. To avoid this slipping it is necessary to pedal very evenly, so as to keep the machine going straight and as nearly as possible upright. The sloping sides of the road must be avoided, and corners must be turned in a careful and deliberate manner. If attention is paid to these points a skilful rider need never slip seriously, though of course much of the pleasure of riding is lost when such great care has to be exercised.

Many people slip over though "losing their heads" directly the back wheel becomes a little erratic, when a more experienced rider would retain his mental and consequently his bodily equilibrium.

A tall rider, with his high saddle and high centre of gravity, is more liable to slip than a shorter rider, as his long slow swing produces more powerful reactions at the foundations of the structure supporting him.

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and one which the author tried in vain to induce Messrs. Lucas to adopt two or three years ago. The valve will also be made so that it can be passed through the rim without being taken to pieces.

Similarly, a high-geared machine is more liable to slip than a low-geared one, owing to the greater pressure required on the pedals, which pressure, lying as it does outside the central plane of the machine, tends to displace the lower portion sideways across the road in one direction, and the upper portion in the other.

Finally, a machine with a wide tread tends to slip more than one with a narrow tread, as with a wide tread the pressure comes further outside the central plane, and its leverage is thereby increased.

The slipping is in no way affected by the kind of gear used to transmit the power from the pedals to the driving-wheel, unless the frame is absurdly flexible, or there are heavy unbalanced moving parts—which, of course, there never are.

The reaction at the ground, resisting these disturbing forces, is limited by the grip of the tyre on the road, and if this fails the equilibrium is upset.

It follows, therefore, that it is desirable to give the tyre as good a grip on the road as possible, consistent with the other duties expected of it.

Many devices have been introduced with a view to giving the tyre a better grip on the road than can be obtained by means of a plain rubber surface, but none of them really make very much difference, except perhaps when they are quite new; while many of them introduced new troubles far worse than the one they attempted to remove.

The author has fully satisfied himself that a plain tyre wears better, and is less liable to puncture than any kind of rough tyre, it is also cleaner and more suitable for use with a brake. He is also quite satisfied that a few concentric ridges, as used on the "Palmer," "Clincher," "Scottish," "Fleuss," "Trench," and other tyres, are as effective as any of the more elaborate forms of "decoration" used by some other makers. Any form of "decoration" (for some of these non-slipping devices are little else) that consists of humps and hollows should be avoided, as the humps tend to flip bits of flint, nails, pins, etc., through the hollows, and brakes tend, sooner or later, to pull the humps off right to the canvas.

If a plain cover or one with concentric grooves be used,

Fig. 61.

the brake is very much less destructive. For fine weather riding, or indeed almost any kind of riding in a flint district, a plain cover is much the most satisfactory thing, and even on a greasy oolite road the advantage gained by the slight roughing that is permissible, is so difficult to gauge, that one is apt to have doubts about its reality. Any roughing that would really penetrate the slime on the surface of the road and reach a firm bottom, would add so much to the rolling friction, or to what might be called the "stiction" of the tyre, as to be out of the question.

We are now in a position to return to the consideration of the rims.

Rims. The function of a rim is, together with the spokes, to retain the wheel in a true circular form, and at the same time to hold the tyre on in some way.

The form of the rim depends upon the method by which the tyre is attached.

Fig. 61 shows a section of a Westwood rim, which is the usual section used with wired tyres. There are two "shelves" on which the wires lodge when the tyre is inflated, and there is a channel between them into which the wires can be drawn when removing or replacing the cover, as already described. The edges of the rim are

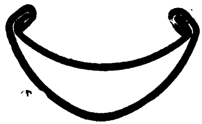

Fig. 62.

turned over so as to form tubes, which add greatly to the strength and at the same time form nice rounded surfaces to get the wires over. This is a very strong and serviceable form of rim, and there being only one thickness of metal for the spokes to pass through, the spokes are more quickly and easily put in than is the case with double hollow rims. The holes in the rim should always be drilled, not punched, as punching leaves the material round the edge of the hole in a condition liable to crack, and cracks in this quarter are rather common.

Fig. 62 shows the type of rim usually supplied with tyres attached by the Bartlett method. It consists of two separate pieces of steel, one forming the outer shell, and the other the inner or concave part. The two are brought together at the edges and bent over so as to retain the ridge on the tyre. The outer piece of metal is also bent over the inner piece, so as to prevent it from coming out, and at the same time it forms a smooth rounded edge which will not cut the tyre. The joint between the two pieces is tinned so as to unite them more perfectly.

In this form of rim both sections of metal have to be drilled, the outside one with holes to fit the rounded part of the nipples, and the inside one with holes about $\frac{7}{16}''$ diameter, to admit the washers that are placed under the heads of the nipples. After the wheel is complete these holes on the inside surface are covered with a double layer of webbing stuck on slightly with rubber solution. This prevents the inner tube from being blown through the holes, and makes a nice smooth surface for the tyre to bed itself on, the spokes and nipples being well out of the way. In the Westwood rims the heads of the nipples trespass into the space intended for the tyre, and special care has to be taken to finish off the ends of the spokes flush, or they will injure the inner tube, notwithstanding the piece of webbing that lies somewhat loosely over them.

With regard to the washers under the nipple heads, these are very necessary with the thin rims now used, as otherwise the nipples would drag right through the rim. The washer spreads the pull of the spoke over a larger area of the rim, and so relieves the immediate neighbourhood of the hole.

Fig. 63 shows a special form of washer, known as the "Woollen Spoke Washer," which is flanged inwards, the head of the nipple bearing on the edge of the flange. These washers keep the pressure well off the edge of the hole in the rim and form an excellent support to the head of the nipple. They are intended for use in the double hollow rims, as they would stand up rather high for the Westwood rims; in fact, the whole question of washers is far more important with the double hollow than with the Westwood rims, as the thickness of the metal is greater in the latter than in the former. With

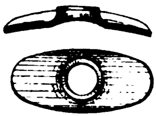

Fig. 63.

tyres of the endless wire variety, also, it is desirable to avoid projections of all sorts inside the rim, as they fill up the channel and make it difficult to get the tyre off, even if they do not injure the inner tube.

With regard to the manufacture of these steel rims; nearly all those for tyres attached by the Bartlett method are made by the Jointless Rim Co., who also make a considerable number of the Westwood pattern, though the bulk of these latter are brazed. The jointless rims are made by first cutting out discs of sheet steel of the very mild kind. These discs are then pressed into the form of shallow pans. The bottoms of the pans are then cut off and the sides remain in the form of endless rings. These rings are then "spun" in a lathe until they have assumed the required shape. For an illustrated description see *Engineering*, September 20, 1895.

The spinning process consists in causing the ring to revolve while a tool is pressed against it, curling it over to the required form. The author has used these jointless rims, both of the Westwood and double hollow patterns, for several years, and sees no reason for buying rims with brazed joints in them, though no doubt some of these brazed rims are very well and carefully made.

With single tube tyres it is the usual custom to use wooden rims. This is partly due to the fact that these wooden rims are unsuitable for detachable tyres, and so they find a market for themselves where they can. They are made up of many pieces of wood so arranged as to "break joint" with one another. They are undoubtedly strong and light, but somewhat affected by damp and other climatic troubles. The chief argument in their favour is that, when used with single tube tyres, they reduce the weight of a machine by a few ounces, as compared with an ordinary double tube roadster.

While speaking of **Weight**, it may be remarked that the difference in this respect between nearly all high-grade machines, is due almost entirely to such parts of the machine's equipment as are optional. A full roadster, with a Brook's B 90 saddle, a Carter gear-case, splash-guards, brake, foot-rests, rubber pedals, pump, spanners and tool-bag, usually weighs from 34 to 36 lbs. If racing tyres, rims, and pedals are fitted, a racing saddle used, and the machine stripped of all the other articles mentioned above, the weight comes down to about 25 lbs. Hence in comparing the weight of one machine with that of another, the equipment of each must be duly considered.

For ordinary road work the importance of this question of weight is usually very much overrated, the real usefulness of the machine as a practical mode of locomotion, being often sacrificed to save a few ounces in its equipment.

CHAPTER VII

GEARING

THE gearing of a bicycle is the mechanism by which the work done on the pedals is transmitted to the driving-wheels. The gearing actually used is almost always arranged so as to cause the wheel to revolve at a greater number of revolutions per minute than the pedals revolve at.

The driving-wheel being usually only 28″ diameter, it is necessary that it should go round from two to three times for one revolution of the pedals, so as to keep the rate of pedalling moderate at ordinary speeds. It is usual to describe the extent of this multiplication by reference to the diameter of the equivalent direct-driven wheel.

For instance, if a machine be arranged so that a 28″ back wheel goes round twice for one revolution of the pedals, it is said to be *geared to* $28'' \times 2 = 56''$, if three times to $28'' \times 3 = 84''$, and so on.

Before discussing gears in detail, a few elmentary principles connected with them all, present, past, or future, had better be made clear, with a view to preventing general misunderstanding, useless discussion, and, maybe, the embarkation of capital in silly schemes that claim to accomplish impossibilities.

We will begin by defining the terms Force, Work, and Power.

Force is defined as *that which produces or tends to produce motion.* This does not tell us very much about force, but if we were to try to penetrate any further into the matter, we also might well be accused of attempting impossibilities. The usual unit for measuring force is *the force exerted by gravity on the mass of a standard pound*, or, in other words, *the weight of one pound*, or more simply, though less correctly, *a pound.*

Work is done when a *force acting upon a body causes that body to move*, and if we measure the distance moved through in *feet* and the force in *pounds*, the unit of measurement of work is one *foot-pound*, being the work done by the force of one pound acting through one foot, the *time* occupied in doing the work being of no consequence.

Power is the word that is used when the *time* taken to do work has to be considered. *Power is the measure of the rate at which work is done.* The usual unit is a horse-power, based on the assumption that a horse can do 33,000 foot-pounds of work in one minute. Let us take a practical example. The author found that he was able to ride up a certain hill in five minutes. He and his machine weighed 208 lbs., and the road rose 199 feet from the bottom of the hill to the top. He therefore did—

$208 \times 199 = 41{,}392$ foot-pounds of work in five minutes, or 8278 in one minute.

His power on that occasion was therefore

$$\frac{8278}{33{,}000} = \tfrac{1}{4} \text{ horse-power, approximately.}$$

It must, however, be noted that this calculation entirely ignores the work expended in overcoming the friction in the machine and on the road, with a solid tyre, and it also takes no account of the resistance of the air, so that the ¼ horse-power is really below the mark.

It will be noticed also, that we have arrived at the work done, and also the power, without knowing anything about the gearing or even the length of the crank. The fact is that neither of these much-discussed things has anything to do with the power required to drive a bicycle, except in so far as some kinds of gearing may introduce slightly more friction than others.

At a given speed a bicycle demands the same amount of power whether the cranks are long or short, and the gearing high or low, supposing that the conditions of road and weather are the same, of course. The choice of gearing or of cranks is entirely a question of physiology, not one of mechanics, except in so far as physiology may ultimately turn out to be some very subtle branch of mechanics.

By the above is meant, that the question is—Can the human body do the necessary work more conveniently by moving the feet slowly through a short stroke, or quickly through a long stroke? Or again, keeping the stroke constant—Can the work be done more conveniently by turning the feet slowly and pressing hard, or by turning them more rapidly and pressing less hard? This is obviously a personal matter, which each rider must settle for himself. In the present state of the public mind, it would be rash to recommend any particular length of crank or any special height of gearing. The author has had occasion to observe that riders who use enormously high gears do not get about the country nearly as well as he does, with quite a moderate gear, and that they suffer much if there happens to be a head wind and rain. However, they appear to derive some subtle satisfaction from these high gears, of which no one has any desire to deprive them. In fact, with extreme gears, the question seems to be one of *psychology* rather than *physiology*, depending as it does on the mental rather than bodily idiosyncrasies of the rider.

There are, nevertheless, a few general observations that may be made on this subject for the guidance of those who have no personal experience of their own. In the first place, as increasing the length of the crank reduces the pressure required on the pedals, and increasing the gearing increases that pressure, it will be evident that if the length of the crank be increased, the gearing naturally should be increased in the same proportion unless the pressure on the pedals is to be altered.

Secondly, if a strong rider wishes to avail himself of his strength by travelling faster than a weaker one, he will, for a given length of crank, go in for higher gearing. Many people, especially when they get past thirty-five, cease to care about riding very fast, even if they can do so comparatively easily. They prefer to travel at a pace that permits of conversation and observation also; in fact, they are apt to regard the juvenile "scorcher" as a species of lunatic, so very different are their respective mental states. To a steady-going rider of this sort very high gear is at no time an advantage, and is a distinct nuisance when riding up long inclines and against head winds. Such a rider usually has his machine geared to about ten or eleven times his crank length, the crank length itself being proportioned to suit the length of his leg, the angle at the knee when the pedal is at the top probably being the determining factor.

Thirdly, if a machine be used for riding on *selected main roads* in fine weather only, a very much higher gear can be adopted than if it is intended for general touring in *selected scenery*, the roads and weather being taken as they come.

Very few people of either sex use cranks less than 6″ long, and on the other hand cranks more than 8″ long are almost equally rare.

Now with regard to the mechanism constituting the gear itself. There appears to be a law of nature which tells us that energy cannot be created, but only transformed. Hence, if you put a certain amount of work into one end of a piece of mechanism, you cannot by any combination of levers or wheels get a greater amount out at the other end. Indeed, practically, a certain amount is always lost in transmission, being transformed into heat by the friction in the gear. If it were not for the fact that several companies have, from time to time, been floated to exploit so-called "inventions," which claim to increase the work done on a machine, without increasing the work done by the rider, it would not have been thought necessary to mention such an obvious truth. There is, of course, a certain class of "inventions" that do add to amount of work done, but they bring into play some kind of "motor," which supplies the additional energy by transforming heat into mechanical work; these, however, do not belong to the subject dealt with in this book.

Chain Gear. We are now in a position to consider gears in detail, beginning with the familiar chain gear. This consists of two specially shaped toothed wheels, known as "sprocket" wheels, connected together by an endless chain. The rear toothed wheel is almost invariably screwed on to the hub with a right-hand thread and locked by a left-hand locking ring, screwed on after it. With this arrangement there is no fear of unscrewing the chain-wheel by back-pedalling, as any such movement tends to tighten the left-hand threaded locking ring. At the same time, should it be desired to change the chain-wheel, it can be removed without difficulty.

The fixing of the front chain or sprocket wheel is not quite such a simple matter. Many makers connect it rigidly to the crank by rivets or otherwise. This is not a good thing to do, as if it should be desired to change it, a new crank also has to be obtained. Again, if an accident occurs and the crank gets bent, it is much more difficult to straighten it when the chain-wheel cannot be disconnected.

One of the best methods of connection is that shown in both Design "*G*" and Design "*H*." A large boss is formed solid with the crank, and hollowed out on the inside so as to allow the bottom bracket to be carried out underneath the chain-wheel. This reduces the boss to a mere flange, on to the outside of which the chain-wheel is screwed with a right-hand thread. On examining the drawings, it will be seen that a left-hand locking ring cannot conveniently be used here, as there is no room for it, and it is not desirable to make room; the wheel is therefore prevented from unscrewing by three small steel set-screws, one of which is clearly shown in each drawing.

This method of attachment has been in use for some

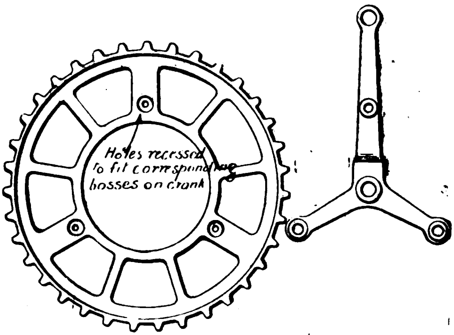

Fig. 64.

years by Messrs. Humber and others, and is, in the author's opinion, quite satisfactory. There are, however, two other methods sufficiently important to deserve description here. The first is shown in Fig. 64. Two arms are forged solid with the crank at angles of 120°. There is a small boss on the end of each arm and one on the back of the crank also. The chain-wheel is bolted against these three bosses by set-bolts, screwed in from the back.

This method allows the bottom bracket to be brought well under the chain-wheel, and also admits of the crank being brought very close in, without making it impossible to get the nut on to the cotter-pin. It is, however, unsuitable for use on a roadster, as it makes a really good gear-case impossible, and on a racing machine the cranks can be brought in still closer by abolishing the cotter-pins and using the method of connection illustrated in Design "*H*," and already described.

The second method of attachment is shown in Fig. 65.

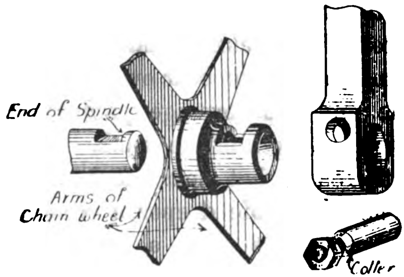

Fig. 65.

A hollow boss or sleeve is formed on the chain-wheel, to fit the crank spindle. The boss of the crank fits on to this sleeve and the cotter-pin passes through both, and so unites the spindle, chain-wheel, and crank, in the way shown in the sketch. This method has been used by several leading makers, and, in a somewhat more elaborate form, is still used on the "Elswick" bicycles. The only objections to it are that it makes the boss on the crank rather large, and it is not so well suited for bringing the bottom bracket out under the chain-wheel as the other two described. There are, however, no additional nuts or screws about it, it therefore scores from the point of view of simplicity. It is also excellently suited for use with the best pattern of gear-case.

Cranks. It will be convenient to discuss here the best section for the cranks. At the pedal end, a crank is subjected to twisting only. The best section is therefore a circular one. At the other end there is rather more bending than twisting, for the twisting remains the same all the way down the crank, whereas the bending increases towards the boss. The leverage producing twisting is, roughly speaking, half the width of the pedal, supposing the foot to bear evenly all across. Near to the spindle end the leverage producing bending is nearly equal to the length of the crank.

It follows therefore that, near the boss, the section of the crank should be made deeper, a rectangular section being more appropriate than a round one. On the whole the author prefers a rectangular section all along, square at the outer end, and increasing in depth towards the boss, but made with the corners well rounded off. His reasons for this preference are, that, in the first place, the section is as good as any other that can be conveniently adopted, and distributes the material in a fairly correct manner. In the second place, the rounded corners help the nickel-plating to keep on, a thing which seems quite impossible in the immediate neighbourhood of sharp corners. In the third place, the perfectly flat and straight front is a great assistance when straightening a bent crank. In fact, cranks that are not perfectly flat and straight along the front, are distinctly difficult to put right when once bent, except with appliances seldom available outside the workshops of engineers. This liability of cranks to get knocked about through causes, often entirely beyond the control of their owner, is a factor that must be borne in mind by bicycle makers.

Arms of Chain-Wheels. For wheels of moderate dimensions, such as are used on ordinary roadsters with gear-cases, simple radial arms of rectangular section are quite suitable. In this case the wheel is stamped in steel, with central boss, arms, and rim in one piece. In the case of the very large wheels that have become fashionable of late, this method of construction is scarcely adequate, as the rim requires more support to keep it true. If it be not true the chain will work badly, and the whole machine will, in consequence, be regarded as unsatisfactory.

A great many strange designs have been introduced, presumably, with a view to getting over this difficulty, but many of them are entirely fanciful and inappropriate, and look like designs for church windows.

Probably the simplest way out of the difficulty is that shown in Fig. 64, which has to some extent been described already. This practically means having three very stout arms for a certain distance out, and then a large number of light ones. This forms an outer ring that cannot easily be distorted, and it also possesses the other advantages already mentioned in connection with the extended bottom bracket, etc. The difficulty about the gear-case does not matter, as nobody who would use a very large chain-wheel would wish to have a gear-case.

Block Chains. The simplest and one of the best forms of chain is the "hardened block" chain, the details of which are shown in Fig. 66. It consists of a series of tempered steel blocks *A*, coupled together by pairs of softer steel side plates, *B*. These side plates are connected by rivets, *C*, passing through the holes in the blocks. One block and a pair of side plates, connected together, constitutes one element, so to speak, of the chain, and is usually 1″ long between the centres, as indicated. This

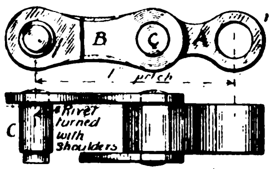

Fig. 66.

distance is the "pitch" of the chain, and consequently is also the pitch of the teeth it works upon.

In constructing these chains, it is a matter of vital importance that the "pitch" should be uniform throughout the whole length of the chain. To insure this, the most perfect machinery, kept in the most perfect order, is required, so that all the blocks may be precisely alike, all the side plates precisely alike, and all the rivets precisely alike. The more perfectly uniform these parts are, the more perfect the chain, and any complications likely to increase the difficulty of making the pitch uniform, or withdraw attention from its importance to matters of less consequence, should be introduced with extreme caution.

The author feels almost justified in saying, that from one cause or another *most* chains, as actually found in use, are appreciably tighter in some places than in others, and not a few are inconveniently slack in some places when almost too tight in others.

Of course, in many cases, this is largely due to the chain-wheels being out of truth, owing to uneven wear in the bearings or inherent defectiveness, but the fault often exists in machines, in which no discoverable cause for

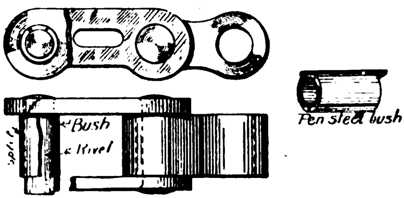

Fig. 67.

complaint can be found against anything but the chain itself.

To return to the details of the block chain, we find the chief point of interest is the rivet. It would be nice to have this hardened like the block, so as to resist wear. This, however, cannot be done by any very simple process, for if the ends were hard it would be impossible to rivet them over. Several of the leading makers cover the middle portion of the rivet with a bush made of pen steel, as shown in Fig. 67, which represents part of a Perry's "Humber" chain. The split in the bush is at the back of the rivet, being the side that escapes the pressure due to the pull on the chain. The bush is prevented from turning round on the rivet by two projecting pieces, which fit into recesses in the side of the hole in the side plate. The use of these bushes does away with the necessity of turning rivets with shoulders on them, as in the Hans Renold chain (Fig. 66), for the ends of the bushes form the shoulders. The author does not wish to pronounce an opinion on the relative merits of the two chains mentioned, as both have

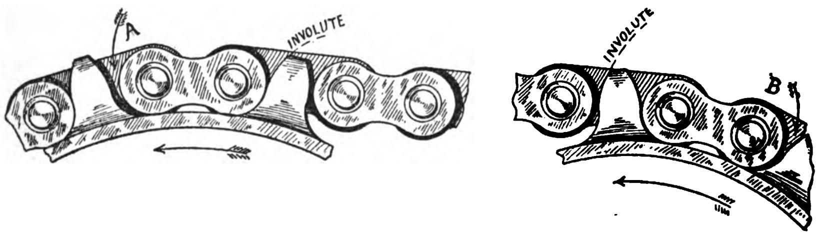

Fig. 68.

served him remarkably well. There is, however, no question about the pen steel bushes being much harder than Mr. Renold's rivets, and it is natural to suppose that they will last longer.

Coming now to the shape of the sprocket wheel teeth and the action of the chain in passing over them, Fig. 68 has been prepared to explain this, and it is to a large extent self-explanatory. It will be noticed that the block does not fit tightly in between two teeth, there is a certain amount of clearance at *A*, so that as the chain coils itself on to the driving-wheel, the blocks do not slide down the backs of the teeth, but drop straight into their places against their front or driving faces. There is also clearance at *B*, so as to prevent a similar rubbing from taking place as the chain uncoils from the driven wheel.

As the chain uncoils from the driving-wheel and coils on to the driven one, the blocks come away from and go on to the teeth with rather more rubbing, since they are held up against the faces of the teeth, the contour of which they follow; but, unless the chain is tighter than it ought to be, the pressures are extremely small, and the friction insignificant.

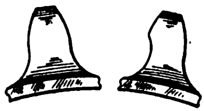

Fig. 69.

The wear that takes place between the blocks and the teeth, as shown in Fig. 69, is caused, not so much by the blocks rubbing up and down the tooth faces, as by their being pressed very hard against the teeth at a particular spot, and then given a very small amount of movement. If the teeth are kept clean and well lubricated, the amount of wear is extremely small, even after travelling thousands of miles. All troubles with chains are due to bad workmanship to start with, or dirt and bad lubrication afterwards, for however hard the blocks and teeth are made, they are bound to wear out if they have to crunch their way along through mud, dust or sand.

Roller Chains. It is customary to make roller chains in one or other of the two forms illustrated in Figs. 70 and 71.

Fig. 70 is what is known as a twin roller chain. This may be described as a block chain, having a composite roller block. The details are shown in the Figure. The object of these rollers is to do away with any sliding that might take place between the blocks and the teeth, and cause it to take place between the inside surface of the roller and the boss or pin that it turns upon. When

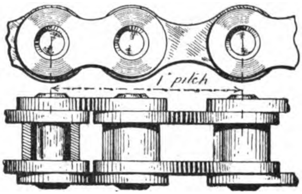

Fig. 70.

the chain is kept clean and well lubricated there is no sufficient reason for doing this, and it is just as well to keep to the simple and eminently satisfactory hardened block chain with pen steel bushes.

When, however, the chain is run in a cloud of dust, or constantly splashed with mud or wet sand, the circumstances are different. The tension in the chain becomes altered by mud collecting on the teeth and blocks, and consequently the blocks have, to some extent, to grind their way in and out of their positions between the teeth. It is then distinctly desirable to transfer the sliding from the external dirty surfaces to the internal comparatively clean ones, where a certain amount of lubricant can have a chance of acting. The running of chains exposed in this way is a barbarous custom, and will be discussed more fully later, under the head of gear-cases.

Referring now to Fig. 71, we find that if the centres of the rollers are pitched at equal distances all along, instead of being arranged in pairs, we get a ½″ pitch and twice as many spaces for teeth. This enables each roller to take

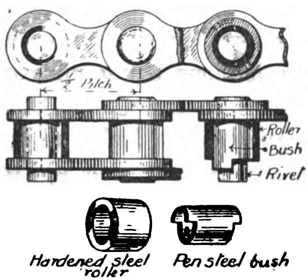

Fig. 71.

its proper share of the work, and so, by spreading the wear, lessens the amount at any particular point. In the twin roller chain, half the rollers only come under pressure when pedalling in each direction, but it is convenient, in that it can be used on sprocket wheels cut for 1″ pitch block chains. If the sprocket wheels are prepared specially for roller chains, the ½″ pitch chain is the natural thing to use.

It will be noticed, that for a given width of chain the surface of contact between the roller and the tooth is necessarily narrower than the corresponding surface in the block chain, and this puts the roller at a slight disadvantage.

The Joint in the Chain. Every chain has a joint in it, to enable it to be taken off without removing the chain-wheel and crank and disconnecting the seat stay, which is, of course, often impossible.

The usual method is to substitute for one of the rivets a steel screw, which is threaded through one of the side plates and fitted with a very thin square lock-nut. The head of the screw should also be as thin as practicable, any large projections being undesirable, as they are apt to catch against gear-cases, etc. Some makers recess the head and leave out the lock-nut, but the author has found that these screws are rather apt to work loose, and if one happens to drop out when riding, the result is exceedingly inconvenient. The disadvantage of the minute projecting lock-nut is much more imaginary than real, while the additional security it affords is most unquestionable.

Lengthening and Shortening Chains. Shortening a chain is a very simple matter. Care must be taken to retain the end of the chain which has the threaded side plate, and to remove whatever may be necessary from the other end. This is done by filing off one head of one of the rivets and then driving it through with a punch, bending the side-plates until the block is clear. The bent side plates remain on the short piece of chain that is removed and are of no consequence. In a roller chain a pair of inside side plates correspond with the block, a pair of outside plates being bent out of the way.

Lengthening a chain is less easy, and if it cannot conveniently be sent to the maker to have the additional piece riveted on properly, an extension with a coupling screw should be obtained. This can be put in without any difficulty, but it adds another screw, which may possibly work loose.

It is most undesirable to entrust the riveting on of the extra length of chain to any ordinary repairer, as he is almost certain to make an unsatisfactory job of it, and one link a little out of pitch, or otherwise defective, will spoil the working of the whole chain.

Adjustment of Chains. Chains should never be allowed to get very slack, as they are then apt to become dangerous, either by coming off bodily, or if there is no gear-case, by catching in the pedal end of the crank. This latter is a most disastrous but fairly common kind of accident. It brings the machine to an abrupt stop, and if the chain does not break, something else must. A pretty considerable wreck is usually the result. The possibility of such an accident is entirely prevented by having a gear-case.

On the other hand, *chains should never be tight.* If they are, they will cause a lot of friction and noise, the teeth rubbing against the chain on what should be the slack side. This produces a cracking sound, which is at once noticeable, and it will also be found that the wheel does not spin freely and stops revolving in an abrupt manner, instead of oscillating backwards and forwards. It is far better for the chain to be a trifle too slack than a trifle too tight.

Lubrication of Exposed Chains. This is a distinctly difficult matter. An oily chain is a nasty, dirty thing, as the dust sticks to it and gets ground up into a black compound, too familiar to need description. If oil is used it should be applied to each link with a small brush, so that it gets well into the joints, all superfluous oil being afterwards carefully wiped off. Another alternative is powdered graphite or black lead. This should be brushed in with ordinary polishing brushes, two being used, one to clean off the dust and the other to apply the fresh graphite. This is rather a dirty job too, but the dust does not stick to graphite as it does to oil.

Exposed chains ought to be thoroughly cleaned periodically, be the job ever so unpleasant.

Gear-Cases. The true solution of the lubrication difficulty, and indeed of all other difficulties in connection with the use of well-made chains, is to enclose the chain in a really well-made and carefully-fitted metal gear-case, which will hold oil. These are generally known as "Carter" gear-cases, and are fitted by most first-rate makers, those on the "Elswick" bicycles being perhaps the most perfect specimens. The author has had a lengthy experience of these "Carter" gear-cases, and has grown to regard them as a most important part of the machine, the improvement due to their introduction being only second to the improvement due to pneumatic tyres. The makers recommend the use of a bath of *ordinary lubricating oil* in them, but the author has reluctantly had to give this up. The use of it practically meant that one could not turn the machine upside down to repair a puncture, nor could one lay the machine on its side, except with extreme caution, and in one way or another, this kind of oil became a nuisance, and was discarded in favour of a more convenient substance, namely, the Cylinder Oil already mentioned in connection with the lubrication of ball bearings. The results obtained by the use of this oil in Carter gear-cases during the last four years have been most encouraging.

The general mode of procedure is as follows:—Having warmed the oil, a sufficient quantity is poured into the case to cover the links of the chain at the lowest point. This will often do for a whole season. As the oil gets spread about the inside of the case a good deal, it is as well every few weeks to warm the outside of the case with a spirit-lamp. This causes all the oil to flow back to the lowest part and lets any dirt deposit at the bottom.

To renew the oil and clean the chain, the plug at the bottom is unscrewed, the case warmed and the oil run out. The plug is then replaced and some paraffin put in. The wheel is then spun round for a time or the machine taken for a short run. The chain will then be quite clean, and on letting out the paraffin any dirt lying at the bottom of the case can be washed out too. A fresh supply of oil can now be put in.

Now as to results. The first thing that is noticed is the extraordinary smoothness and silence with which the chain runs. The second is, that the chain seems never to require adjusting, and by degrees its very existence becomes almost forgotten, for it practically never requires attention of any kind, except at long intervals of time, and even then one does not actually see it. This the author regards as a most blissful state of affairs.

To be more precise about the adjustment, the author can quote two cases. The first is his present machine, which is now in the middle of its third season, and has never had its chain adjusted since the first month it was in use. The second is a machine he possessed previously, and which is now in the possession of a friend, who uses it fairly constantly. The present chain has been on the machine since the latter part of 1895 or the early part of 1896, and as can be seen by looking at the chain-adjusters now, has never been adjusted to an appreciable extent. In fact, it has never been intentionally adjusted at all, but as the back wheel has had to be taken out from time to time to replace worn-out tyres, the chain has had to be taken off, and when put back may have been adjusted to a very slight extent.

It may be remarked, that this oil confines itself to its proper functions, and does not get about on to the outside of the case or other parts of the machine, as although it flows slowly it cannot be induced to splash, except in extremely hot weather.

As to the other features of these gear-cases, it must be remembered that even if the chain be oiled in the ordinary way without a bath, *it is kept clean, which is most important*, and the case admits of its being washed with paraffin, which is a most convenient and expeditious way of performing more complete cleansing. These gear-cases also form a thoroughly permanent and satisfactory part of the machine, for *if properly fitted to start with*, they do not

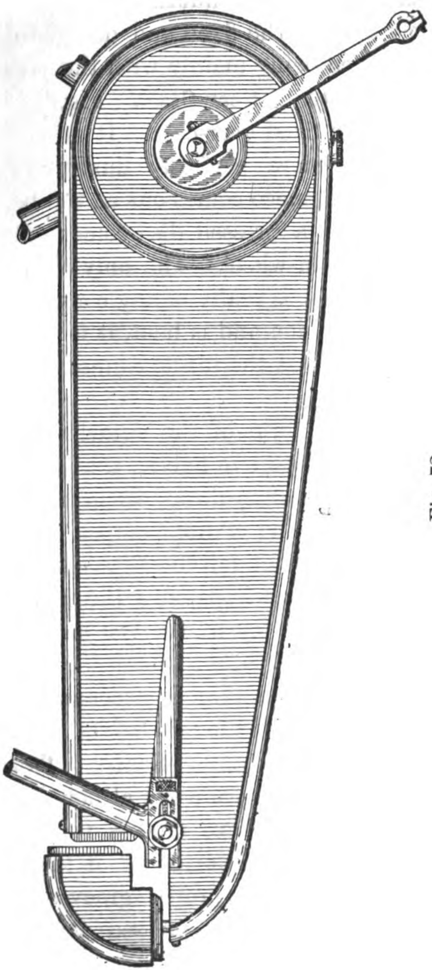

Fig. 72.

rattle or make themselves a nuisance in any way. These remarks apply to both the fixed and detachable cases, the author's experience being mainly with the latter kind.

Details of "Carter" Gear-Cases. Fig. 72 shows the general form of the fixed gear-case. It is soldered to the frame, and so is more perfectly dust-proof than any detachable case. A piece comes out at the back to admit the back wheel, and a pressed disc comes out in front to admit the large chain-wheel. The only objection to this type of gear-case that is really of any consequence, is that if it gets into a collision and is bent, it is an awkward job to put it right again, as the inside cannot be got at at all easily.

Fig. 73 shows one form of the detachable case. It is divided horizontally into two halves, the joint being carefully made so as to exclude dust. It is held in its place on the machine by a kind of fin, clamped on to the frame, and fitting into grooves at suitable places in the two halves of the case. Two screws, passing through the bracket that holds the "fin," finally fix the two halves of the case in position.

To detach the case, all that is necessary is to remove these two screws and pull the two halves apart, they then come clear away without any difficulty. To put the case together is not nearly so easy, for although it is merely necessary to reverse the above process, it is apt to require a good deal of care before the edges of the various parts are all imbedded in their proper grooves. That being done, the halves are merely pressed together and the screws inserted.

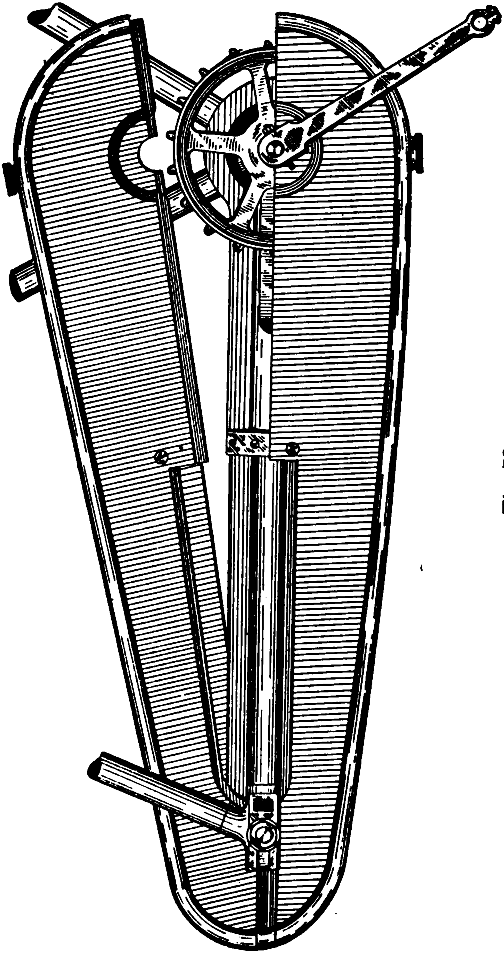

Fig. 73.

Slides at the Back of Gear-Cases. It is usually necessary to have slides at the back of the gear-case, both on the outside and inner hub side, to allow the chain to be adjusted. These are often rather a nuisance, owing to the frame of the machine not allowing sufficient room, or being otherwise awkward. Undoubtedly from our present point of view, the best plan is to build the machine to suit the case, when, of course, the thing can be done properly, as on the "Elswick" bicycle. In detachable cases the slides on the inside are often a trouble; they are apt to project

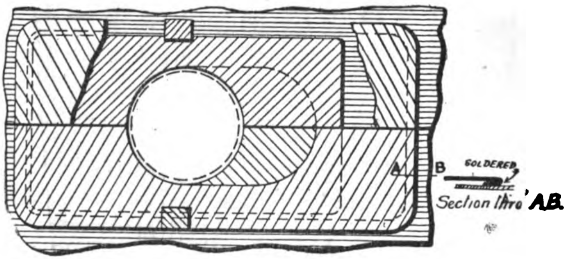

Fig. 74.

and get caught in the ends of the spokes, and they add somewhat to the trouble of putting the case together. The author has put these slides on the inside of his case, leaving the outer surface near the spokes free from projections. The slides are of fairly stout metal, and though they move freely in a horizontal direction, they cannot move vertically, or be detached from their respective halves of the case (see Fig. 74). They do not have to be considered at all in putting the case together or taking it apart, as if they happen to be a little bit out of position the round surface of the hub guides them into their proper places, and moves them also when the chain is adjusted, the action being entirely automatic. It might be supposed that slides which move horizontally as freely as this would make a noise, by constantly chattering against the hub. The author has been on the look-out for this, but can discern no signs of anything of the kind. The vibration appears to move the slides just clear of the hub, and leave them there.

Other Gear-Cases. With regard to other gear-cases, they are made for the most part of celluloid, leather, or a combination of the two, and there are, of course, many metal cases that are not at all suitable for use in the way described above, and must be put in the second class along with these others of "lesser degree."

Most of these cases are untidy-looking things, that have to be taken to pieces whenever the chain has to be cleaned, and the cleaning done by some more or less disagreeable manual process. Many of them are also very apt to get out of shape and rattle, and none of them are as dust-proof as a properly fitted metal case. They are, however, cheap, and that is often important. A reasonably well-made leather or celluloid case is certainly far better than none at all, particularly, of course, on a ladies' machine or a "mixed" tandem.

The author feels bound to insert a word of warning with regard to gear-cases of all sorts, and especially those made entirely of metal or celluloid. A badly-fitting gear-case is always a nuisance, and may be positively dangerous, hence it should be put on the same footing as a dress-coat, and always *made to order to fit the machine, never bought ready-*

made. The machine should be sent to the maker of the gear-case, not the gear-case to the maker of the machine. Several of the large firms make both machines and good gear-cases, and then the matter is simple, but when that is not so, it does not do to be put off by assurances that the case will fit, be they ever so confident. Most people do not seem to know what the word "fit" means as applied to gear-cases.

Measurement of "Gear," with Chain Gearing. As already explained, the height of the gear on any machine is obtained by multiplying the diameter of the driving-wheel by the number of times it goes round for one turn of the pedals. With chain gearing this is got at from the number of teeth on the chain-wheels, by simply dividing the number on the large wheel by the number on the small. For instance, if there are nine teeth on the back hub and twenty-seven on the crank sprocket wheel, one turn of the cranks will cause the back hub to turn $\frac{27}{9} = 3$ times. Again, if there are ten teeth on the back hub and twenty-nine on the crank sprocket, one turn of the cranks will cause the back hub to turn $\frac{29}{10}$ times.

With a 28″ wheel the first gives $28 \times 3 = 84''$, and the second gives $\frac{28 \times 29}{10} = 81{\cdot}2''$.

Size of Chain-Wheels and Chains. At a given speed, the pull on the chain is proportional to the diameter of the back chain-wheel, and is entirely independent of the height of the gear or the length of the crank.

In the first class the rim of the larger sprocket wheel is expanded, thereby increasing its circumference, and consequently increasing the gear also. This of course requires a longer chain. Hence, a lot of slack is left in the chain to admit of these variations, the chain being prevented from coming off or swinging about by a "jockey" pulley resting on the lower or slack part. It is obviously not possible to back pedal with such a chain, and indeed no

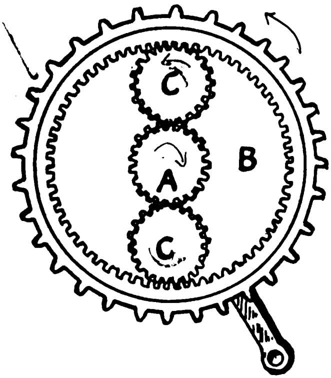

Fig. 78.

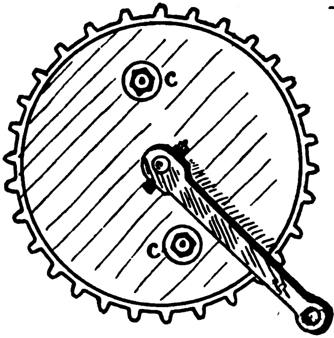

Fig. 79.

attempt is made to make it possible, for the cranks are arranged to drive forward only, the mechanism actuating the variable gear being adjusted by turning the cranks round in the reverse direction through a short distance.

The construction of the second class is illustrated in a diagrammatic way by Figs. 78 and 79. The two toothed pinions *C* are connected to a disc rigidly fixed to the crank. The annular toothed wheel *B* carries the larger sprocket, while the toothed wheel *A* can be thrown into gear with the crank or fixed to the bottom bracket by means of a clutch actuated from the handle-bar. The action is as follows. If *A* be fixed to the crank, the toothed wheels cannot move relatively to one another, and the whole mechanism goes round as one piece. If, however, *A* be fixed to the bottom bracket it cannot revolve, and the pinions *C* will roll round upon it and cause the outer wheel *B* to move round faster than the cranks. The extent of this increase may be shown by an example. Suppose there are twenty teeth on *A* and one hundred on *B*. Then, if the cranks remain still, and *A* turns round backwards at the rate of five turns per second, *B* will go round forwards at a rate of $5 \times \frac{20}{100} =$ *one* turn per second. Now turn the whole mechanism round at the rate of five turns per second in a forward direction. This reduces the supposed five turns per second of the wheel *A* to nothing, or in other words, makes it a fixture; it causes the cranks to go round at five turns a second, and the chain-wheel at $5+1=6$ turns per second.

In other words, the pinions *C*, in rolling round the outside of the fixed wheel *A*, add the circumference of this wheel to that of the wheel *B*, making *B* equivalent to a wheel having 120 teeth. Hence, if a machine were geared to 65″, when the mechanism was revolving as one piece, it would be geared to $65'' \times \frac{6}{5} = 78''$, when the mechanism was at work. Of course a much greater range than this can readily be obtained if desired.

For a more full account of these and other two-speed gears the reader is referred to Mr. Sharp's work on *Bicycles and Tricycles*.

CHAPTER VIII

MISCELLANEOUS FITTINGS

Handle-Bars and Handles.—The usual method of constructing handle-bars is to lap the upright tube that fits into the head around the horizontal tube that forms the bar itself, and then braze the two together. The way in which the upright tube is shaped to form the lap is shown

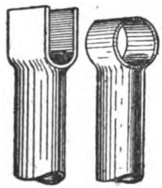

Fig. 80.

in Fig. 80. This makes a very satisfactory job, and there seems to be no reason for changing it. To braze the handle-bar into a lug projecting in front of the upright post is obviously unmechanical, and is only done to suit the irrational fancies of fashion. On the "Elswick" bicycle a different method is adopted. A T-shaped stamping is made, bored right up the post and through the cross-piece, and machined all over the outside as well. The hollow cross-piece thus takes the place of the lap. This is no doubt a first-rate job, but surely a trifle extravagant. It might be remarked, that the post is graduated on the outside to assist adjustment.

Shape of Handle-Bars. This is a delicate subject, involv-

Fig. 81.

ing as it does the position of the rider. There are two positions in which a man can ride, the upright and the racing position. The first is that in which Nature intended a man to ride, and the only position in which it is possible for him to derive the greatest benefits from cycling. The second is the position that it is necessary to adopt in order to reduce wind resistance to a minimum, and to obtain the utmost possible speed regardless of everything else.

Fig. 81 shows the first position and Fig. 82 the second, as seen on the road. So far as road work is concerned, this is another of those psychological questions, which,

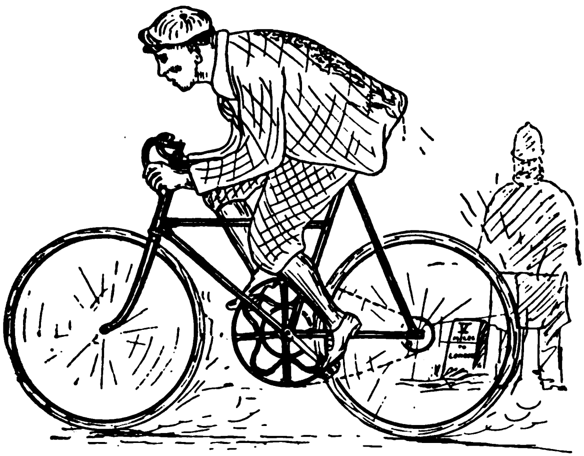

Fig. 82.

however, is usually more or less answered by the expression depicted on the countenance of the rider.

Handles. The choice lies between indiarubber, felt, and cork. Indiarubber wears best, and is most easily attached to the handle-bar by means of cement; it is, however, inclined to get a little sticky in hot weather. Felt is much used, and is probably the most suitable substance. Cork is pleasant to hold, but wears badly, and does not adhere to the bar very well.

Brakes. Many people ride on the road without brakes, and probably will continue to do so until they are obliged by law to do otherwise. Their objection to brakes is, presumably, that they add a few shillings to the cost of the machine, though the reason they usually give is that they add to the weight. That this latter notion is merely an excuse and not a reason must be obvious to all experienced riders. Weight can only be regarded as an objection when it is a hindrance. It is true that if a machine were used on level roads only, a brake would be superfluous, though how its weight could act as a hindrance on a level road would be difficult to explain. Most people like to feel that they can go anywhere they please on their machines, and in all ordinary districts the saving in time and energy effected by the brake is very considerable, unless the brakeless machine is ridden downhill with criminal recklessness. If a machine has no brake, and back-pedalling is alone relied upon to check its speed on a steep hill, it must always be kept well in hand, and the result is, as the author has observed on innumerable occasions, the rider with the brake simply sails past the one without the brake, and reaches the bottom refreshed in body and mind, while the brakeless man is having a hot and even anxious time of it, very likely a quarter of a mile behind. The only compensation he has is, that he is relieved from hoisting brake tackle up the hills, which, considering the insignificance of the weight concerned, is a very miserable recompense. At first sight it seems somewhat contradictory that a brake should be the means of obtaining additional speed down hill, but still that is undoubtedly the fact. A man who has the means of checking a machine if he wishes to do so, can travel at a far higher speed downhill than one not so provided, and if he is lucky in finding the road clear at all the hills, he may complete a long ride without using the brake at all, nevertheless, the presence of the brake has enabled him to keep his feet on the rests and travel at a high speed, while in its absence he would not have been able to do so without grave risk. Of course, there are many districts in which it is utterly impossible to ride down the hills at all without a brake, and its utility in such districts does not need to be pointed out.

Details of brakes. Brakes may be divided into three classes—tyre brakes, rim brakes, and drum brakes.

Dealing first with tyre brakes. Many people seem to have an absurdly exaggerated idea of the damage that these brakes do to the tyres. This has probably arisen through their experience, when they really have any, having been gained with unsuitably designed brakes or unsuitably designed tyres (see page 134).

There seems no doubt that indiarubber is the best material for the rubbing surface of the brake. Its coefficient of friction is large, and hence a light pressure is sufficient. The rubber can be fastened on in a variety of ways, the main things to see to being that it can be easily removed and replaced when worn, and that the method of attachment is really strong. One of the most convenient methods of attaching the rubber is that used in Hall's brake, Fig. 83. A spindle passes through each block, as in ordinary pedal bars. This enables the blocks to be turned over when worn, and is a most satisfactory arrangement. There are, of course, many others of equal merit, the matter having received considerable attention.

Methods of applying tyre brakes. These brakes are usually applied to the front wheel because they cannot very conveniently be applied to the back, which is obviously the better place.

A good deal has been said by various people about the stress produced in the crown of the front fork by a front wheel brake, but all well-made crowns are quite able to

Fig. 83.

stand this, as they are designed to resist shocks from big stones and ruts, which are often much more severe than anything produced by a brake used in any rational way. The chief objection to the front wheel tyre brake is that it covers the machine and its rider with dirt. This is specially the case, so far as the rider is concerned, when he has his feet on the rests, his stockings and knees getting in a horrid mess. These front wheel brakes are nearly always applied by a direct plunger tube, worked by a lever attached to the handle-bar, in a manner probably quite familiar to any reader of this book. It is advantageous to hinge the brake block by an arm connected to a lug at the *back* of the crown, as shown in Design "*G*," and to have the spring on the handle-bar. A very good kind of spring is shown in Fig. 84. It is made of steel wire, and is held in place by having its ends put through a hole in the underside of the handle-bar. If the spring is at the bottom end of the plunger it is apt to get clogged with dirt. Plungers hinged in this way work more pleasantly than those which slide through a hole in a boss projecting in front of the crown, as grit will sometimes get jammed into the hole, by lodging on the lower part of the plunger

Fig. 84.

when the brake is "on," and then getting driven in tight by the sudden release. This often makes the plunger grind and work stiffly in the hole.

When a tyre brake is used on the back wheel, and the power is transmitted by rods, bell-cranks, etc., the arrangement is complicated and apt to rattle. Pneumatic brakes are used a good deal as a way out of this difficulty. These brakes are applied by inflating a kind of bellows by means of a ball squeezed by the hand, and fitted with small automatic suction and delivery valves.

It is released by letting the air out through a third valve which is opened with the finger. These brakes keep themselves on if the valves are in good condition, which is a slight convenience, though they are not sufficiently powerful to do the work of which an ordinary plunger brake is capable with a very moderate amount of exertion with the hand. It is therefore quite unfair to make any remarks about aching fingers, as by that time the man with the pneumatic brake would be walking. Another objection to pneumatic brakes is that it takes a very appreciable length of time to get them on at all powerfully, which renders them almost useless for emergency stops.

There is another and much more satisfactory solution to the back wheel brake problem which will be described among the brakes of the next class.

Rim brakes. Brakes applied to the rim instead of to the tyre have come into vogue very much of late, and there is undoubtedly a great deal to be said in their favour. They consist of a couple of blocks of fibre, leather or rubber which are drawn or pressed up against the inside surfaces of the steel rim on each side of the spokes.

Front wheel brakes of this type are usually applied by means of the ordinary plunger mechanism and some arrangement of levers, though it would seem more rational to put the fulcrum of the hand lever on the far side of the upright tube, and draw the blocks straight up by means of a tension rod, the blocks being attached to a kind of horseshoe similar to that in the brake to be described next.[1]

[1] Messrs. Humber make a good front wheel rim brake, constructed in this way.

This is the extremely ingenious and original back wheel rim brake invented by Mr. E. M. Bowden. The special feature of this brake is the flexible cord employed for transmitting the power from the hand to the brake itself. It is composed of a stranded tension wire enclosed in a tube consisting of a closely wound helix, also made of wire. The outside of this tube is covered with some kind of fabric, which protects it and gives to the whole the appearance of a flexible cord. The special construction of the tube gives it flexibility, but enables it to offer as much resistance as any other tube offers to having its length shortened. Hence, if its two extremities are gripped firmly, the internal wire can be drawn through, even though the intermediate portion of the cord is hanging in loops.

Fig. 85 shows the general arrangement of the brake. The blocks are attached to a kind of horseshoe, which rests against the back of the seat stays, and they are kept clear of the rim of the wheel by springs attached to clips fastened on to these stays. This extremity of the helical tube fits into a socket in a bridge which clips on to the seat stays a few inches above the splash-guard. The tension wire comes out an inch or two beyond the end of the tube, and has a large spoke nipple soldered to its extremity, the spoke nipple being clamped to the horse-shoe carrying the brake blocks. The unprotected end of the wire is covered with a little indiarubber tube, which contracts in "concertina" fashion as the wire is drawn into the helical tube.

At the handle-bar there are two devices in use. In

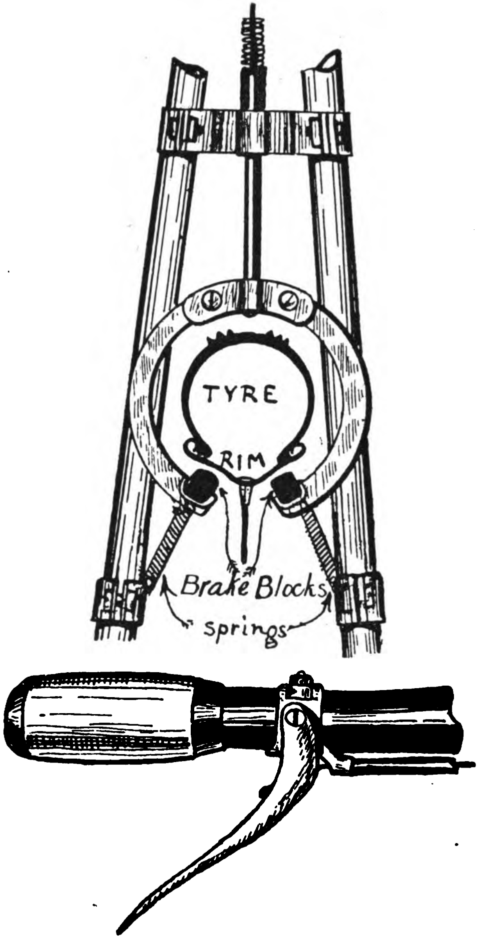

Fig. 85.

one, the cord is taken through a hole into the interior of the handle-bar and fastened to a fitting inside. The tension wire is connected to the handle itself, which turns on the bar, working on what is equivalent to a coarsely pitched screw thread. This handle, when turned, screws itself along the bar and pulls the wire. In the other device there is a lever as shown in the figure. On gripping this in the usual way, the wire is drawn through its helical tube and the brake applied, the wire being attached to the lever, and the end of the tube to the clip that connects the arrangement to the handle-bar.

The twisting handle and internal cord is undoubtedly the neater arrangement, but it is more expensive, and involves cutting the handle-bar. The lever requires no special fitting, and seems to be generally preferred, notwithstanding the fact that the twisting handle will hold the brake on without any exertion on the part of the rider.

So far as the author has, at present, had time to observe, this brake seems remarkably satisfactory, and he has found it an excellent solution to the difficulty of applying a brake to the back wheel of a tandem in which the lady controls that on the front wheel. One is apt to feel a certain amount of hesitation about applying a brake to such very thin rims as are used with "Palmer" and other Bartlett tyres, and if rim brakes are going to be used a great deal, as seems likely, it might be desirable to go in for a slightly stouter gauge of steel for the part of the rim affected.

Drum brakes. These were much used in old days on tricycles, and when they can be made large enough they work well. They are largely used on winches, cranes, motor cars, traction engines, steam rollers, etc., but are apt to be considered rather too complicated and cumbersome for a bicycle.

The essential features of a drum or band brake for a bicycle are a drum several inches in diameter and about $\frac{3}{4}''$ to $1''$ wide, and a steel band lined with leather. The drum is usually fixed to the hub of the driving-wheel, and is encircled by the band. The end of the band, which has to resist the pull, is connected to some fixed point on the frame, while the "tail" of the band is pulled by means of some arrangement of bell cranks and rods. The difficulties to be got over in applying these brakes to bicycles are almost all due to the fact that the movement available with an ordinary grip lever is so small. If the diameter of the drum is also small, the leverage must be increased, and the movement proportionally reduced, in order to get force enough to produce the necessary friction. This small movement makes it very difficult to get the band well away from the drum when the brake is off, and consequently, as the band nearly always gets out of shape after a time, it is very apt to rub somewhere or other when it is supposed to be clear.

Increasing the width of the drum is useful to prevent it from getting hot, but it does not increase the power. The only real way out of the difficulty is to have a good big drum about five or six inches in diameter, but that is heavy and ugly. When small drums are used a great deal of friction is required on their circumference to check the machine, as the frictional force acts with such a small leverage. To get this friction the leather must be run dry; or even treated with resin. The brake is then very apt to squeak and work in a jerky manner, going on very strongly at first and easing off as it gets warm with use.

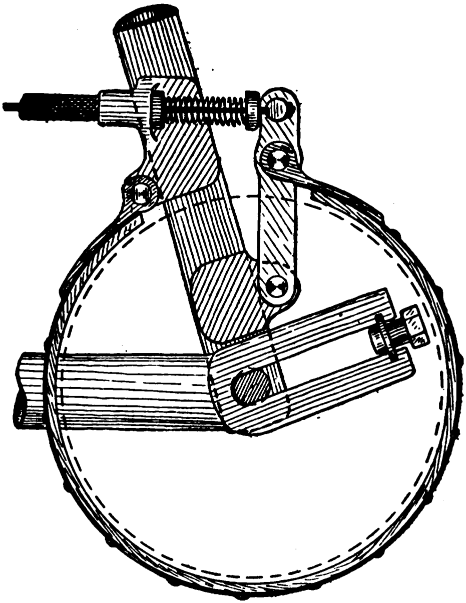

Fig. 86.

It is not very easy to say why the coefficient of friction of leather on iron decreases as the temperature rises, but it certainly does do so in a most marked way. It may be due to the heat drawing some kind of grease out of the leather. The author has possessed one safety bicycle, two tricycles and one tandem tricycle with band brakes, and has tried quite a host of others at one time or another. He has found that the only ones that work really nicely, are those which are sufficiently large to be powerful enough when the leather is the least bit greasy. They then work smoothly, do not squeak, and are less affected by temperature than when dry. Apart from the above-mentioned difficulties, there still remains the one of transmitting the power from the hand to the brake. This is usually done by rods and bell-cranks, though there seems no reason why Mr. Bowden's device should not be used for such a purpose. Fig. 86 suggests such an application of it. This would also get over the difficulty about the amount of movement, as, by using the twisting handle, any amount of movement could be obtained without reducing the leverage.

Saddles. These are generally clamped to a horizontal piece of tube about $\frac{7}{8}''$ diameter, which is brazed to the top of another tube, that fits inside the diagonal of the frame. The connection between these tubes is made in precisely the same way as the connection between the handle-bar and the steering tube. Vertical adjustment is given to the saddle by sliding the inclined tube up or down in the diagonal, and fixing it by means of the clip, which has already been described. Horizontal adjustment is obtained by moving the saddle clip along the horizontal tube, this clip also allowing the saddle to be given more or less tilt.

About the best design of under-frame and clip for a saddle is that shown in Fig. 87. This was at one time used by Messrs. Brooks on the B90 and other saddles. The clip now used allows the saddle horizontal adjustment independently of the seat pillar, and is capable of being used on a plain pillar without any horizontal tube at all. When these two requirements are insisted on, the old clip, shown in the figure, is unsuitable, but under all ordinary conditions it supplies all necessary adjustments and is a much firmer attachment than the new one. The

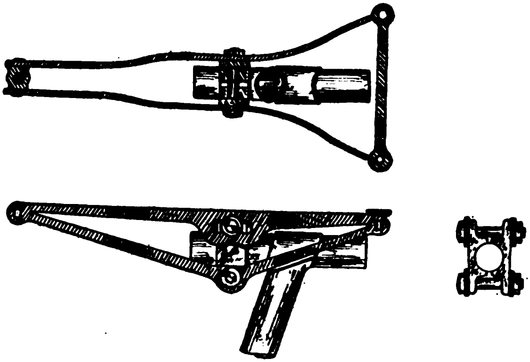

Fig. 87.

author possesses two of the new kind and one of the old, and most certainly prefers the old pattern.

Above the under-frame we find the springs and frame for holding the leather, that is to say, if there are any springs. Most saddles met with on the road have no springs, though the frame is sometimes made a little tortuous, to suggest the idea of springiness to the imagination of the rider. It is quite possible to get accustomed to riding on a hard saddle, and some people seem to like it, but when one is accustomed to riding on a springy one like a Brooks' B90, a hard one is apt to be positive torture, particularly if the rider's bones are not well covered. The author would be very sorry indeed to have to ride for forty or fifty miles at a stretch on a saddle without springs, he would certainly have to get off and walk for a while after the first thirty miles, to change the distribution of pressure, and restore the circulation. This is perhaps due to his having been "spoilt" by Mr. Brooks' springs for a considerable number of years. Be that as it may, it seems reasonable to suppose that it is

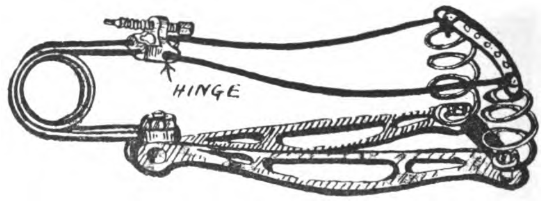

Fig. 88.

better and less tiring for the rider to have the incessant bumping from the road reduced as much as possible.

Fig. 88 shows an excellent arrangement of springs for a man's bicycle, while Fig. 89 shows an arrangement suitable for either sex. Large numbers of each kind are in use, the details being slightly modified by different makers. Whatever arrangement of springs is used, it is desirable that they should be able to resist the backward thrust on the saddle that occurs when riding up-hill. In Fig. 88 the front spring resists this, while in Fig. 89 the piece of steel wire about $\frac{1}{4}''$ diam. marked *A B* does the work. This wire has a hinge at each end, so as to enable the saddle to move up and down, side rolling being allowed for by making the hinges an easy fit.

With regard to the shape of the leather seat, much might be said by a doctor, though the author has observed that doctors who ride much have very little to say on the subject, and moreover, they generally ride on spring saddles of the ordinary type. If the rider sits moderately upright, with the saddle in a reasonable position, by far the greater part of the weight comes on the prominent

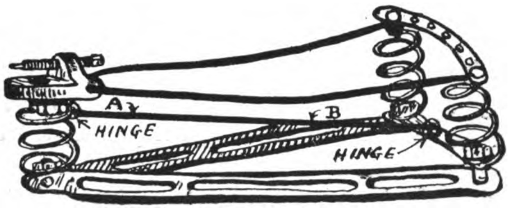

Fig. 89.

parts designed by nature to support it. Numbness may be produced in this quarter if the saddle is too hard, and it may be necessary to change the position, or get off and walk for a time, in order to allow the circulation to recover itself, and restore the compressed parts to their normal state. This trouble usually occurs at the beginning of the ride during the first long run, and does not return again after a short rest, even though the ride be continued through the rest of the day; moreover, it is not injurious, but merely inconvenient.

With regard to pressure on the perineum caused by the peak of the saddle being pushed right up into the fork. This usually arises from bad riding in a bad position. Except occasionally, when thrown forward by some quite unexpected and unusual jerk, a good rider will never experience any appreciable pressure in this quarter. Sometimes irritation may be caused by the seams of the trousers, forming a lump, especially if the material is rather thick, but this can usually be avoided by a little special attention to the "make up" of the trousers, and by having a good big hole or depression along the ridge of the saddle. This hole or depression allows the clothes room to keep out of the upper part of the fork and so all pressure is avoided. A depression with rounded edges is better than a plain hole, as the edges of the hole are apt to chafe the part of the trousers that comes in contact with them.[1]

As a rule the peak presses, not up into the fork, but sideways against the muscles running down the inside of the legs from the fork. Doctors do not appear to regard pressure here as in any way more objectionable than pressure on any other muscles. If too severe and prolonged it produces a numbness, which passes off after a short rest, and seldom comes back again for a considerable time. This kind of discomfort is usually due to the position of the rider, or the rate of pedalling being different to what he is accustomed to.

It is important, of course, to keep the leather properly

[1] The author has found "Pattison's Hygienic Elswick D" saddle to suit him so far as shape goes, and the under-frame and fittings are exceptionally well-made.

stretched by means of the screw usually found under the peak, as if it sags too much in the middle, the peak becomes unduly prominent, and the shape of the saddle distorted. It may be as well to point out, that it must not be supposed that the position obtained by placing bare bones on a saddle will be the same as the actual position in life, when the bones are raised off the saddle by the thick muscles which cover them.

Foot-rests and Free Pedals. All machines that have brakes should also have foot-rests in some shape or form. Fig. 90 shows the usual form of foot-rest that is clamped

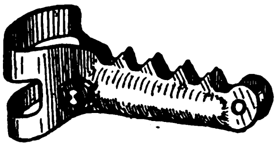

Fig. 90.

to the front fork. These are best made as shown, with a single bolt on the outside of the fork and no projections on the inside. The rest opens at the outer end, so as to enable it to be put on without taking out the wheel. If these rests are the proper size for the fork, they hold on very tightly, and never slip down with fair usage. If they do slip down, the absence of any projections on the inside enables them to keep clear of spoke ends, cyclometer pins, etc., and so no harm is likely to result. Their weight is entirely insignificant. It has often been a matter of surprise to the author that so many riders go about without foot-rests, as the pleasure of running down long hills with the feet "up" is not one that he would willingly forego. The position is so comfortable, the mere change of position so agreeable, and the sensation of rushing through the air at twenty to twenty-five miles an hour without any labour, so exhilarating, that people who have not experienced it can hardly be regarded as genuine cyclists.

In the northern counties wonderful things can be done with the feet "up." The author has repeatedly travelled stretches of three, four, five or even six miles in this way, the six miles in question taking from eighteen to twenty minutes, the road running over an open moor for the whole distance. There are also many fine runs in the Chilterns, Cotswolds, Mendips, Surrey Hills, and in Devonshire and Cornwall, though the Devonshire roads are apt to be rather too rough and precipitous for "coasting."

There is a certain risk of catching cold on these long runs, and it is therefore desirable to button up one's coat well before starting, particularly if a long climb has just been completed.

With regard to free pedals or free wheels. This is a return to the fashion of old days, when the "Cheylesmore" tricycle was to the fore. In the case of these tricycles the free wheels were unavoidable, and when the "Salvo" tricycle became properly known, it and its fellows rapidly ousted the free wheel machines. However, free wheels have come to the fore again, and, for certain classes of riders, they no doubt have advantages.

The usual method of construction is to run the back chain-wheel on a silent ratchet or clutch of some sort. Fig. 91 shows Morrow's Patent Clutch, which is one of the best at present in use. The inner wheel, which is fixed to the hub, is made with teeth having slightly inclined backs. A hard steel roller rests in the hollow of each tooth, and when the outer wheel is driven round in the direction of the arrow, these rollers work up the inclined backs of the teeth and get jammed. If the outer wheel is kept stationary, the inner one can continue to revolve, the rollers sliding down into the hollows again. The rollers

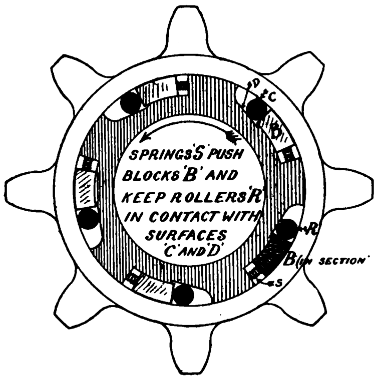

Fig. 91.

are kept close up to their work by little blocks pushed forward by springs.

As back pedalling is impossible with this mechanism, brakes have to be entirely relied upon to check the machine. It is usual to fit a special brake, which is, as a rule, applied to the rim of the back wheel, by pressing on the pedals in the reverse direction. Fig. 92 shows one such arrangement, as made by the Wilkinson Sword Co. A second silent ratchet is fitted on to the crank spindle inside the left crank. When pedalling forwards this ratchet is *free*, and that on the driving-wheel *in gear*. On the rider

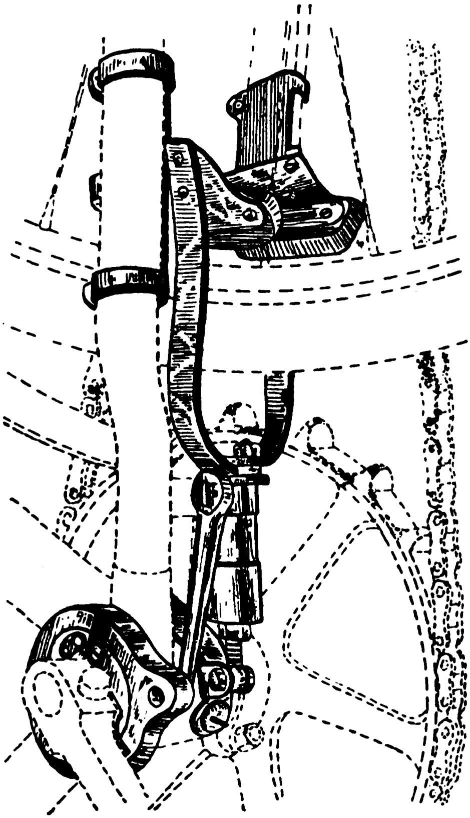

Fig. 92.

attempting to pedal backwards, the ratchet on the crank spindle instantly comes into gear, and a further movement of the cranks draws on the rim brake, which is clearly shown in the figure.

In some machines the brake ratchet is actuated by pegs on the spokes of the sprocket wheel, which engage in a pawl attached to the brake mechanism, but this is apt to interfere with the gear-case.

As to the general question of free pedals *versus* foot-rests, it is doubtful whether the ordinary, more or less athletic male rider will ever be much interested in free pedals, or care to complicate his machine with silent ratchets and foot brakes, but with ladies the case is rather different. If foot-rests are used there is always more or less risk of the pedals catching in the skirts and causing an accident, and ladies are apt to find it a little difficult to get the feet on to the pedals when they are revolving somewhat rapidly. It is therefore a distinct advantage, from their point of view, to be able to keep the feet on the pedals always, and nevertheless obtain rest when running down-hill. The position with the feet on the stationary pedals can hardly be compared to that with them on the foot-rests, and the perpetual use of a powerful rim brake on every trifling occasion, as well as on steep hills, is bound to produce a good deal of wear and tear in course of time.

Splash-Guards. Many riders never use splash-guards, and when a machine is intended for use on dry roads only they are naturally not needed. But in a climate like ours the intention is apt to be frustrated, and splash-guards, like an umbrella, are almost a necessary part of an Englishman's equipment. The "scorcher" with the wide line of mud right up his back to his hair is a fairly familiar object-lesson, and needs no comment here. The most permanent and satisfactory guards are made of sheet steel, pressed into the correct shape and "beaded" or turned over at the edges. The section of such a guard is shown in Design "*G.*" Care should be taken to avoid projections of all sorts on the inner surface of the guards, as they collect the mud, and any fittings that are attached to the guards should be riveted and *brazed;* riveting alone is not sufficient, as the rivets work loose with the vibration.

The chief objection that is raised against these metal

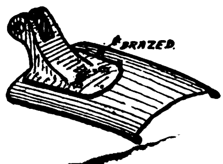

Fig. 93.

guards is that they rattle, and no doubt many of them do. This is, however, entirely unnecessary, and due to mere slovenliness in fitting, or to absurd clips and complications intended to facilitate the removal of the guards. As a rule these contrivances are most successful, as the guards are speedily removed and consigned to a place from which there is no return. The author has used metal guards most persistently for many years, and never has the least trouble with them, but he is able to make his own fittings, which, however, are of the simplest possible description.

The best way to connect the front guard to the crown is by means of a hinge, the bolt passing through an eye projecting at the back of the crown. The fitting attached to the guard should be a "double eye," as shown in Fig. 93, brazed on of course. The bolt is screwed through the far side of this double eye, and is then fitted with a lock nut. The stays connecting the guard to the centre of the wheel

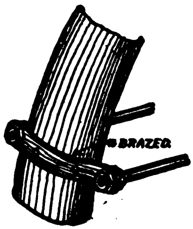

Fig. 94.

should be made of $\frac{3}{16}''$ steel wire of fairly hard quality, and they should be connected to the guard as shown in Fig. 94. In the case of the front wheel, these stays should always be connected to the spindle of the hub by having

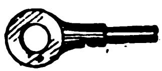

Fig. 95*a*.

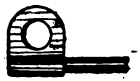

Fig. 95*b*.

washers formed on their ends, which go under the lock nuts. These washers are best made separately and screwed on to the stay very tightly (see Fig. 95*a*), as if made out of the stay itself they are rather apt to crack. In the case of the back wheel the same arrangement can often be used, and when that is so, it is the best thing possible, for not only does it involve no extra nuts or clips, but it pushes the guard back as the chain is adjusted, and so keeps it concentric with the wheel. Sometimes the stay gets in the way of the chain-adjusting nut. This can usually be overcome by making the washer as shown in Fig. 95*b*; this brings the stay lower down, and enables the spanner to get at the nut. On some machines, notably the "Elswick" and the "Osmond," the stays cannot con-

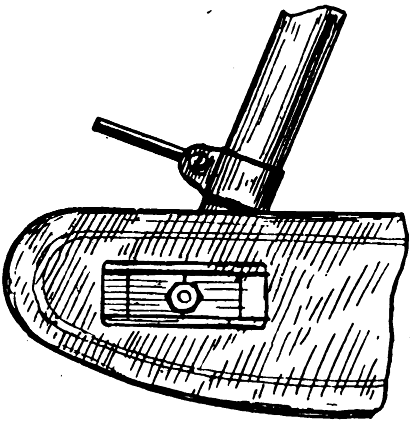

Fig. 96.

veniently be connected to the spindle, and the idea of pushing the guard back by means of the chain-adjuster has then to be discarded. This is not of any very great importance with first-class machines fitted with gear-cases, as the chain stretches so little that it takes a very long time before the wheel gets noticeably nearer to the guard. Under these circumstances it seems best to connect the guard stays to the seat stays just above the level of the gear-case, as shown in Fig. 96. This has a very neat appearance, and keeps the stay away from the gear-case, against which it is sometimes apt to rattle.

With regard to the attachment of the back guard to the bridge near the bottom bracket, this is best effected by means of a $\frac{1}{4}''$ bolt with a flat round head and square neck. This bolt is put through from the wheel side, and fitted with a nut *and lock nut* on the other side, a leather washer being inserted between the guard and the bridge. The two nuts are desirable, as if only one is fitted it has to be screwed up very tight or it will work loose. It is not desirable

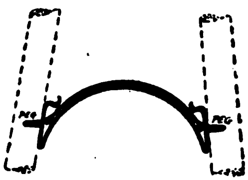

Fig. 97.

to have it screwed up in this manner, as the guard ought to be able to "work" a little between the cup head of the bolt and the leather. If it is screwed up tight with one nut, it will almost certainly creak, and very likely work loose. When the two nuts are used the joint never gives any trouble, and the cup head on the inside does not project enough to catch the mud, and never needs touching with a screw-driver or spanner. If the tyre is *very* close to the bridge it may be a little awkward to push the bolt out, and should this be the case the tyre must be partially deflated. The attachment to the bridge between the seat stays may be made in the same way, whether this bridge be brazed on or detachable. From our present point of view the brazed bridge is the best thing, as it involves no extra nuts or screws. When there is no bridge some other plan has to be adopted. Fig. 97 shows the method used on the "Osmond" bicycle, which is one of the simplest. The guard is attached to a light spring fitting, which carries two pegs, which fit into small holes drilled through the inside surface of the seat stays. The pegs can be withdrawn by pinching in the fitting carrying them.

On American machines splash-guards are frequently made of wood, and are a good deal too short to be of any real service. The guard of the back wheel should be extended until its extremity meets a vertical line drawn to touch the tyre, and that of the front wheel should go close to the ground, the last few inches being made of leather so as not to catch against large stones, etc.

Luggage Carriers. The carrying of luggage on a bicycle is always rather a difficulty, not so much on account of its weight as on account of its bulk, and the difficulty of attaching it so that it shall be out of the way of everything. The author has spent quite a lot of money at one time or another on bags and carriers, and has come to the conclusion, that the people who make these things never really use them or understand in detail the requirements of tourists. All sorts of silly flaps, buckles, clips and other "rattle-traps" are fitted, which have afterwards to be removed, and the actual capacity of the majority of these bags is most limited, and they are often very inconvenient to pack.

There are four different places on a machine where luggage can be carried, namely—in front of the head, on the handle-bar, in the frame between the legs, under and behind the saddle.

For tall riders the last method is much the best, it being possible for them to carry quite a large bag there, out of the way of everything, and in an excellent position as regards distribution of weight. One method of carrying luggage in this position is shown in Fig. 98*a*, but it is, unfortunately, unsuitable for the majority of riders, as there is not sufficient room between the saddle and the

Fig. 98*a*.

splash-guard. Another method is shown in Fig. 98*b*, and is known as Turner's " Bi-Carrier." It consists of a light but strong detachable frame on which a bag of very considerable weight can be safely carried. It is, however, not in a very convenient place for a light bulky parcel, as anything projecting very much, either sideways or behind, in this quarter is apt to get in the way when mounting or dismounting.

Many people carry their luggage in the frame, and bags made for that purpose look very promising at first sight.

They are, however, distinctly disappointing. If they are

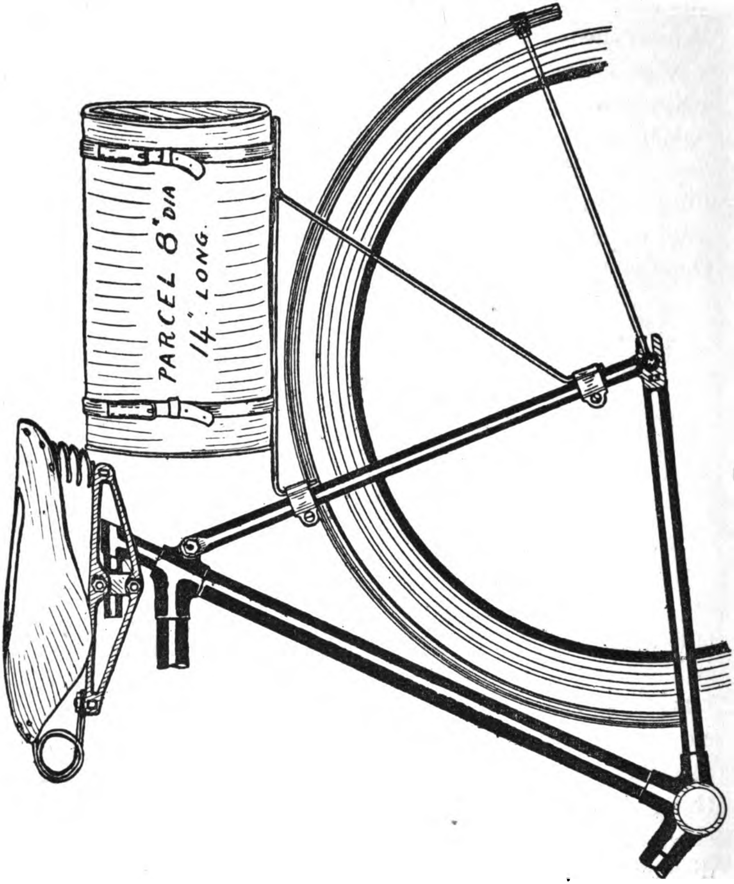

Fig. 98*b*.

made stiff enough to be packed *tightly*, they are very cumbersome, and if they are not stiff, very little can be packed into them without causing them to bulge and rub against the knees in a most uncomfortable way. A certain amount of luggage can be carried in front, on a frame clamped to the head. This position is suitable for a parcel about the size of a "Kodak," but is not adapted for anything very bulky, as the frame then projects a long way in

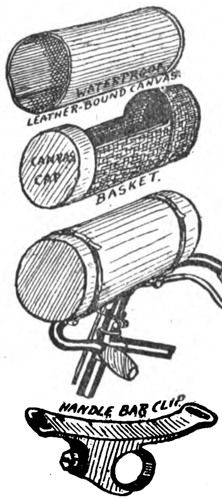

Fig. 99.

front, and is very unsightly. It is also undesirable to have to clamp a frame of this sort on to the head of the machine whenever it is necessary to carry luggage.

The author, after trying every way of carrying luggage, has returned to the handle-bar method as being on the whole the most convenient. A small quantity of luggage may be carried here by simply rolling up the loose articles, such as washing and shaving tackle, in the softer articles such as flannel shirts, and packing them in a "hold-all" of waterproof material, which is strapped on by means of a couple of Lucas's "King's Own" handle-bar clips. When more is required the author uses a cylindrical basket covered with waterproof canvas, as shown in Fig. 99. He gets these baskets made by a basket maker, Mr. R. G. Moon, 12 Lower Park Row, Bristol, and the canvas case by a saddler. The case consists of a cap permanently fixed to the basket, and a loose cylinder, closed at one end and open at the other. The basket is first packed and then slipped into this canvas cylinder, being strapped to the handle-bar by means of the clips already mentioned. The straps belonging to the clips are the only ones required, and the whole thing is neat, simple, and quite waterproof and dustproof.

The baskets are 16″ long and 8″ in diameter and weigh with the case when empty 1 lb. 9 oz. When filled with the articles enumerated below the weight is 5 lbs. 12 oz.

1 Nightshirt.
1 Flannel Shirt.
1 Pair of Drawers (short).
1 Pair of Stockings.
1 Pair of Slippers.
1 Razor in case.
1 Strop.
1 Shaving Brush.
1 Tooth Brush.
1 Hair Brush and Comb.
1 Sponge in Bag.

It is found that this comparatively light weight, symmetrically situated as it is on the handle-bar, makes no perceptible difference to the steering. When more than this has to be carried, it becomes necessary to have two parcels, one being placed behind the saddle, on a Turner's carrier or otherwise.

On the tandem two of these baskets are carried, and a small bag behind the saddle as well. For an extended tour these baskets are obviously insufficient, and Parcel Post has to be made use of. A pair of so-called Japanese baskets, which fit into one another, are used. They are covered with American cloth and encircled by a single strap. The external dimensions of the pair, when inside one another, are $18\frac{1}{2}'' \times 12'' \times 6\frac{1}{2}''$, and their weight empty, but complete with strap and covering, is $2\frac{1}{2}$ lbs. The depth may be increased to considerably more than $6\frac{1}{2}''$ by not telescoping them right into one another. At the present time the limit of weight is 11 lbs., which goes for one shilling, and it is found that that limit is reached before the baskets are expanded to their full capacity. Clothes travel remarkably well in this way, and the baskets appear to stand many journeys without suffering appreciably.

Spanners. Every machine should be sent out with a set of spanners that will not only fit every nut on the machine and adjust every bearing, but things must be so arranged that every nut and every bearing can actually be got at, easily and conveniently, by these spanners. This is a severe test, and few machines will stand it. There is nearly always an obscure nut somewhere about the machine or the saddle that cannot be manipulated.

Small makers will often send out their machines with an adjustable spanner. This is a very slovenly way out of the difficulty. The adjustable spanner will almost certainly be quite unsuitable for adjusting the bearings, and will probably be unsuitable for getting at many little nuts about the machine owing to the thickness and width of the jaws. Again, an adjustable spanner should only be used by a man who is more or less of a mechanic, and who also has some degree of patience. If used carelessly, it will ruin the corners of the nuts, and the

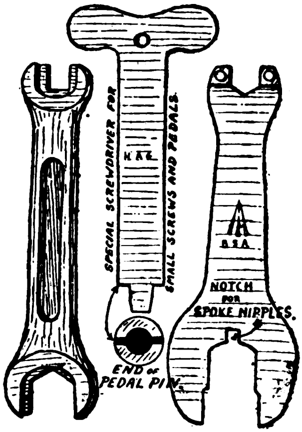

Fig. 100.

knuckles and temper are apt to suffer as well. Fortunately many makers are now fully alive to the importance of good spanners, and send out their machines properly equipped.

In Fig. 100 is represented a complete set of tools necessary for a machine made up of B. S. A. fittings. The two spanners, except for the notch for the spoke nipples, are as sent out by the Company, the screw-driver is an addition, made out of spring steel $\frac{1}{16}''$ thick. The projecting end of this screw-driver is for ordinary small screws such as occur on gear-cases and brake fittings, while the two shoulders are for unscrewing pedal pins, which are screwed into the cranks with ends as shown in the sketch. The whole lot weighs under $4\frac{1}{2}$ oz., and satisfies every possible requirement on the machines referred to, provided the nuts on the saddle are made to conform to those on the rest of the machine. This can be readily done by reducing them with a file, if they happen to be rather too large for one part of the spanner and too small for another, and it is a far better thing to do than adding to the number of spanners.

Cyclometers. Cyclometers are now so very generally used, that perhaps the reader may be interested in the following explanation of the most usual pattern, known as the "Veeder." The instrument consists of a small cylinder, $\frac{3}{4}''$ diameter, which is attached to the spindle of the front wheel by a neat little bracket, that allows the position of the cylinder and star wheel to be adjusted sideways to suit the spokes. A small peg clamped to a spoke engages in the star wheel, which has five arms. Hence five revolutions of the bicycle wheel cause the star wheel to make one revolution.

Inside the cylinder there are five rings carrying black figures on a white ground, these figures being visible through a piece of glass let into the upper part of the cylindrical surface. The outside or right-hand ring indicates fractions of a mile in eighths or tenths, and it goes round exactly once for each mile. The next ring indicates units, and goes round once for every ten revolutions of the first ring. The other three rings indicate tens, hundreds, and thousands respectively, and

Fig. 101.

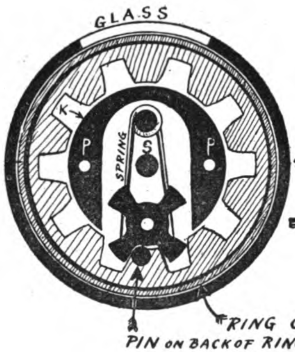

Fig. 102. Fig. 103.

they each go round once for ten revolutions of the ring next in order towards the right.

Let us first consider how the ring indicating the fractions is caused to go round once for each mile travelled. The particular cyclometer that the author has examined is intended for a 28″ wheel revolving 720·28 times per mile, if no allowance is made for the shortening of its circumference by the compression of the rubber tyre; but, as will be shown, it requires 728·33 revolutions to indicate one mile on the cyclometer. Whether these eight revolutions per mile neutralize the effect of the reduction in the circumference of the rubber tyre precisely

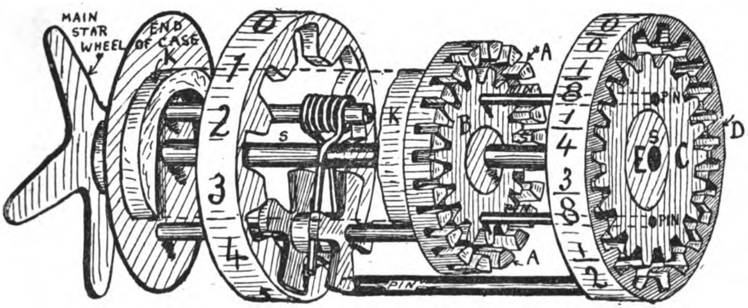

Fig. 104.

or not, the author cannot say, as there are wobbles also to be allowed for, and milestones are not entirely to be relied upon. The error is therefore rather difficult to determine, but it is certainly very small.

Turning now to Fig. 101, in which the wheels are shown as plain circles without teeth. *D* is the ring carrying the fractions, and it has twenty-three teeth on its inner surface. This gears at *L* into the wheel *C*, which has twenty teeth on its circumference. To the back of *C* a third wheel *B* is fixed, having nineteen teeth. This gears into the fixed ring A (shown black), which has twenty-two teeth on its inner surface, and is prevented from turning round by the pins P, Fig. 102.

The five-armed star wheel is fixed to the spindle S, which has an eccentric disc E fixed to its other extremity. The wheels B and C turn on this eccentric disc as on a spindle, it being concentric with their circumferences.

Fig. 104 is a perspective sketch of the mechanism for working the fraction and unit rings. The length of all pins and spindles is exaggerated to separate the parts, so as to make them visible. The action is as follows:—

The star wheel causes the disc E to travel around the centre of S like a crank, having a throw equal to the distance from the centre of E to the centre of S. This causes the wheel B to roll round the inside of the fixed toothed ring A, and at the same time to turn slowly round its own centre. When so turning it carries with it the wheel C, to which it is fixed by two pins, and this wheel C gives to the ring D a slow movement in the opposite direction to that of the spindle S and the star wheel.

To find the relative movements of the ring D and the spindle S, suppose the fixed ring A to turn round the opposite way to a clock through one revolution, and the spindle S to remain stationary. The revolution of A will cause B to turn round $\frac{22}{19}$ times, and B, being fixed to C, will cause D to turn round $\frac{22}{19} \times \frac{20}{23}$ times, also in a direction opposite to that of a clock. Now turn *the whole mechanism* round in the same way as a clock, and at the same rate as that at which we suppose A to be revolving. This keeps *A* still, as it ought to be, causes the spindle *S* to turn round one revolution in the direction of a clock, and the ring *D* to turn round

$\left(\frac{22}{19} \times \frac{20}{23}\right) - 1$ revolutions in the opposite direction.

Hence one turn of the star wheel corresponds to

$$\left(\frac{22}{19} \times \frac{20}{23}\right) - 1 = \frac{3}{437} \text{ revolutions of the fraction ring.}$$

And as the star wheel has five arms, one turn of the bicycle wheel corresponds to

$$\frac{3}{437} \times \frac{1}{5} = \frac{1}{728{\cdot}33} \text{ turns of the fraction ring.}$$

That is, the bicycle wheel turns $728{\cdot}3\dot{3}$ times for each "cyclometer mile."

Turning now to the mechanism for actuating the other rings, we find that at the back of each ring there is a small pin, which engages in a minute star wheel once at each revolution. This star wheel also gears into teeth on the inside of the next ring. As there are ten of these teeth, and the star wheel only moves forward through one tooth each time it comes in contact with the pin, it follows that it requires ten revolutions of one ring to give one revolution to the next.

To prevent the star wheels moving from vibration, etc., while the pin is not in contact with them, small springs are arranged to grip them and cause sufficient friction to keep them still. This mechanism takes some time to describe, but it is in reality exceedingly neat and simple, and not at all likely to give trouble. It is entirely enclosed, and does not need oil, and so its existence is never in any way apparent to the rider.

Rotameters. These instruments, though much less used by cyclists than cyclometers, are really much more useful, as they tell you how far you have to go before you start, which is much more important than telling you how far you have been when you have finished. The author always regards his cyclometer as a toy, an entertaining and companionable toy, but still only a toy. His rotameter he regards as almost a necessity. It is a little nickel instrument like a very small watch. A small wheel projects slightly at one part of its circumference, and this can be rolled along a map. A train of wheels inside gives readings in inches and fractions with the long hand, and feet with the short hand.

When used on the excellent reduced Ordnance maps published by Bartholomew, the readings are accurate enough for all practical purposes.

The instrument can be carried either on the watch-chain like a locket, or, if preferred, in the pocket. They may be purchased from almost any mathematical instrument dealer for 4*s.* 6*d.* in nickel, or 7*s.* 6*d.* in silver. The author has had his for about ten years, and it is still as good as new. He does not know by whom they are actually made.

Bells and Lamps. This chapter seems scarcely complete without some reference to bells and lamps. With regard to the former, it need only be remarked that there are now several really good bells on the market at a moderate price, and no one should have any difficulty in distinguishing a good well-made bell with a clear tone from an inferior one.

As to lamps, the matter is much less simple. The choice lies between ordinary colza oil lamps, paraffin lamps, candle lamps and acetylene gas lamps. To properly gauge their relative merits is a problem from which the author shrinks. They are all more or less of a nuisance.

The really important things to see to in selecting a lamp, are its general design and workmanship. The body of the lamp and the springs at the back should be really well-made, so that they will not come to pieces or rattle; for it must be remembered that when touring, the lamp has to be carried all the way, whilst in the summer months, at any rate, it may be only used occasionally for an hour or so, and the amount of light it gives then is of very little consequence, so long as it satisfies the local policemen. In winter and the late autumn, the light of the lamp is occasionally of real use to the rider, the nights being really dark. Under these circumstances a good lamp is important, and lucky is the man who has one that will enable him to see a cart thirty yards off when he is riding at twelve miles an hour. As a rule the light merely dazzles the rider and makes everything around appear impenetrably dark. The light on the road is so peculiar and irritating to the eyes, that it is almost impossible to distinguish any details unless the road is dry and white, which it seldom is in the winter, except when covered with snow.

The purport of these remarks is intended to be, that the amount of light given by a lamp is seldom enough to be of any real use, as what one really wants is a little light a long way ahead, not a very bright patch just in front of the machine. Hence it is usually sufficient just to keep the lamp alight, so that it indicates to other people the approach of the bicycle but does not dazzle the rider. For such purposes candles certainly ought to be much the most cleanly and convenient method of illumination.

THE END.

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