July 29, 1952 E. W. SMITH 2,604,669

DOFFER COMB

Filed Oct. 13, 1950

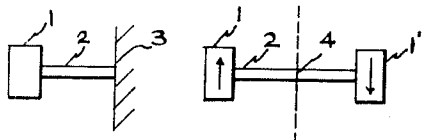


Fig. 1

Fig. 2

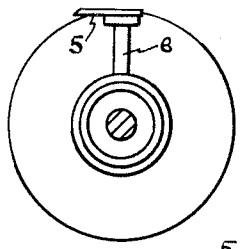


Fig. 4

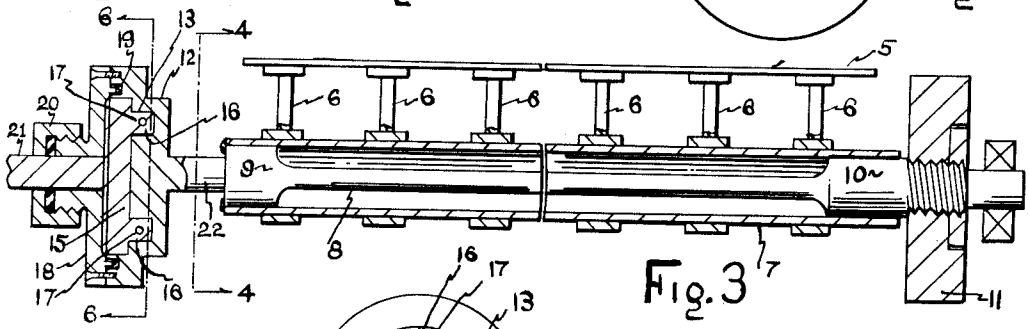


Fig. 3

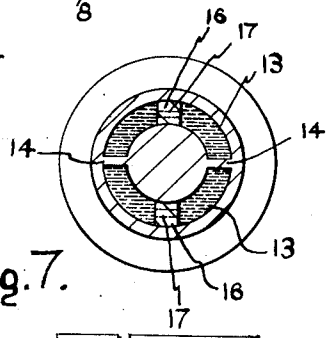
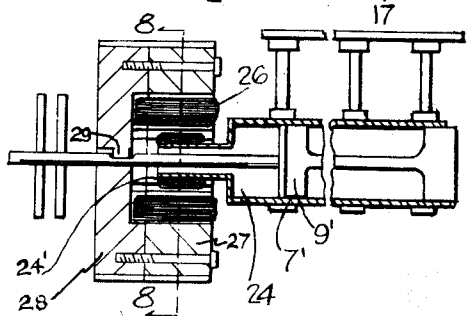


Fig. 6

Fig. 7.



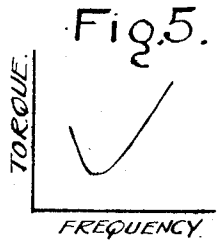


Fig. 5.

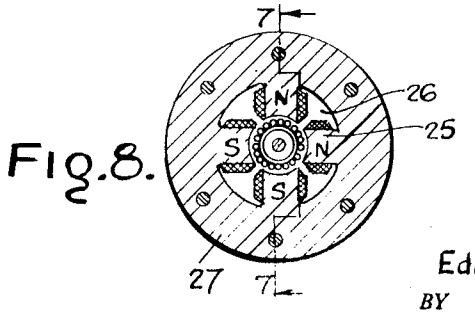


Fig. 8.

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DOFFER COMB

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12 Claims. (Cl. 19—106)

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The present invention relates to doffer combs which are used in removing fibers from wire cylinders and other type cylinders of carding and other machines.

In the preparation of many types of fibers for subsequent processing into yarn, felt, etc., it is common practice to partially at least, align the fibers involved by passing them through a carding machine. The various steps through which the fibers are passed need not be discussed here since the operation is well known to those skilled in the art of such fiber preparation. At the output end of the machine the more or less oriented fibers are picked up by a slowly revolving cylinder whose wire studded surface carries them in the form of a thin web from which the web is removed by the doffer comb.

In practice this comb consists of a metal strip with a serrated edge which is made to oscillate through a small angle tangent to the cylinder so that in the course of operation the web is removed continuously from the surface of the revolving cylinder. Furthermore in the course of removal a substantial amount of extraneous material such as bits of leaves etc., in the case of cotton, are dislodged from the web by the impact of the comb in removing it from the cylinder. While it is current practice to apply the necessary torsional movement of the comb about the axis on which it oscillates by means of an eccentric mechanism, there are definite limitations to the speed at which the comb can be made to oscillate by this means because of its inertia which in turn, causes unnecessary wear and tear, difficulties on the eccentric mechanism, lubrication difficulties and many other problems which are present at higher speeds of the usual mechanism used. It is the purpose of the present invention to disclose a method and means whereby the necessary torsional acceleration of the comb about its supporting axis can be accomplished conveniently at much higher speeds than heretofore and at the same time reduce or minimize the extra stresses which would otherwise be imposed upon the comb eccentric mechanism.

The present invention also provides a mechanism which will operate and start with a minimum of power and will have its forces and stresses balanced so that there will be comparatively little vibration outside of the vibratory elements of the comb itself.

The merits and advantages of the present invention will be more readily understood from the specification below when taken in connection with the drawings illustrating an embodiment thereof in which—

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Figures 1 and 2 show diagrammatic illustrations for explaining the principles of the present invention.

Figure 3 shows a longitudinal section through a doffer comb of the present invention.

Figure 4 shows a section on the line 4—4 of Figure 3.

Figure 5 shows a torque frequency curve of the operation of the present invention.

Figure 6 shows a section on the line 6—6 of Figure 3.

Figure 7 shows a section on the line 7—7 of Figure 8 of a modification of a detail of Figure 3, and

Figure 8 shows a section on the line 8—8 of Figure 7.

The principles of the present invention can best be understood by reference to Figure 1, where, in schematic form, is shown an inertia element 1 solidly secured to one end of a shaft or the like 2, having a torsional stiffness. The other end of shaft 2 is solidly secured to a solid body 3, large compared to the inertia element 1. If now the inertia element 1 is rotated slightly about its axis this action will result in torsion being applied to shaft 2, and when the torque which brought about the rotation of element 1 just referred to, is removed, element 1 will oscillate torsionally at a frequency which is determined by the magnitude of its inertia and the torsional stiffness of shaft 2.

While such a system can be made to have any desired frequency and angular amplitude of vibration, it presupposes that the supporting body 3 be large compared to the inertia element 1 which is not always easy to achieve. A closer examination of the problem will indicate what is really needed at the point where the body 3 is secured to the shaft, is not so much an infinite mass as it is a torque which is at all times equal and opposite to the torque delivered to shaft 2 by the oscillation of inertia 1. If this could be achieved and applied to the end of the shaft secured to body 3, the purpose of body 3 would be achieved because at this point there would be no rotation of shaft 2 and the need for a large body 3 could be avoided.

The method by which the need for a more or less infinitely large mass to which the end of shaft 2 is secured, can be avoided, is shown schematically in Figure 2. Here we have the same inertia element 1 secured to a shaft 2, but in this case shaft 2 is made longer and a second inertia element 1′ is solidly secured to it at the opposite end from inertia element 1. If now torque is applied to inertia elements 1 and 1′ in the direc-

tions indicated by the arrows, and then released, inertia element 1 will oscillate as before and inertia element 1' will also oscillate but in the opposite direction at all times. Thus at the nodal point 4 the forces exerted on the shaft 2 will be equal and opposite with a resultant absence of motion of the shaft at this point and, insofar as inertia element 1 is concerned, the effect of the solid member 3 is obtained but without the need of its size and mass.

It is, in effect, as if a mirror image of the inertia element 1 and shaft 2 had been introduced in place of member 3 and with the same physical effect.

The means by which the above principle is applied to the high speed operation of a doffer comb will now be described in connection with Figures 3 and 4.

The comb 5 is carried on supporting arms 6 which, in turn, are solidly secured to a tube 7. One end of the tube 7 is solidly secured to a torsion shaft 8 at the enlarged head 9, by welding, force fit, or other suitable means. The other end of the tube 7 is free to turn on the enlarged end 10 of shaft 8. Furthermore an inertia element 11 is solidly secured to this same end of the torsion shaft 8 as shown. In practice I prefer to have the inertia element 11 so designed that it will have the same inertia as the combined inertia of the comb 5, support arms 6, and the tube 7 so that the nodal point or point of zero angular rotation of shaft 8 will occur at the center although this is not necessarily essential as will presently appear.

Assuming that a frequency of oscillation has been chosen and an angular amplitude of oscillation, the maximum torque required to give the necessary acceleration to the inertia of the combination of comb 5, support arms 6 and tube 7, can be determined from the relationship

$$\text{Torque} = 12 J_m \alpha \omega^2$$

where Torque is the torque required in inch pounds J_m is the mass moment of inertia in pound feet squared of the above combination, ω is 2π times the frequency in cycles per second, and α is the angular amplitude of motion in radians.

In this connection it should be remembered that such a comb would normally be operated on a 24 hour/day basis, more or less, and therefore the maximum fiber stress in the torsion shaft should not exceed a safe value which I prefer to set at 15,000 lbs./ sq. in.

Having determined the required torque as above, the necessary shaft diameter to ensure that this fiber stress will not be exceeded may be determined from the relationship

$$d = \sqrt[3]{\frac{16T}{15{,}000\pi}}$$

where d is the torsion shaft diameter in inches, and T the maximum torque required in inch pounds.

The length of shaft required may be determined from the relationship

$$L = \frac{(3400d^2)^2}{Jf^2}$$

where L is the active length of the torsion shaft 8 from the nodal point to the point where it is solidly secured to tube 7. Since as mentioned above, I prefer to make the inertia of the counterbalancing inertia element 11, the same as that of the tube-comb assembly, this in effect

means that the nodal point will be at the middle of torsion shaft 8 and L then becomes ½ of the total length. d, in the above equation is the shaft diameter in inches as determined above, f the required frequency of oscillation in cycles per second, and J the moment of inertia of the comb-tube assembly on a weight basis, i. e. the sum of the weights of the various components times the square of their distance from the axis of oscillation in inches.

Since the physical shape of the counterbalancing inertia can take many forms, its construction will not be discussed here in detail except to point out that its moment of inertia J', on a weight basis, should be the same as the moment of inertia J which can be arrived at as indicated above.

It should also be kept in mind, that although mention has been made of the inertia of certain specific parts of the tube-comb assembly such as the comb, support arms, and tube, the inertia value used in computing the torque required and the torsion shaft length and diameter should include these elements plus any other inertias connected to this assembly and oscillating with it which may be involved in the construction and operation of the assembly.

In considering such a system as has been described above it will be noted that it is a mechanically resonant system and the torque required for its operation at frequencies both on and off resonance follows a curve substantially as shown in Figure 5. As will be noted from this curve the pulsating torque required to maintain the system in oscillation at frequencies other than the resonant frequency is much greater than that required at resonance.

One of the purposes of the present invention is to provide a simple and effective mechanical means for bringing the oscillating system up to the resonant frequency and thereafter supplying it with such torque as may be necessary to take care of the load. The method and means by which this is accomplished can best be understood by reference to Figures 3 and 6.

Referring now to Figure 3, a casing 12 is provided with an annular groove 13 divided into two semi-circular compartments by the dividing members 14. A matching element 15 (Figure 3) is provided with ears 16 whose inner and outer surfaces are curved and have the same radii of curvature respectively as the inner and outer curves of the annular groove 13 in the casing 12. These ears are provided with holes 17 forming an interconnecting passage between the two flat surfaces of the ears. If now member 15 is placed in position on casing 12 with ears 16 projecting into the two annular compartments formed in groove 13 by dividing member 14, element 15 may be rotated through a substantial angle back and forth since the inner and outer curved surfaces of ears 16 match snugly but without undue friction, the inner and outer curved surfaces of the two chambers. It will also be noted that a cover plate 18 and a sealing ring 19 are provided to make the two chambers just mentioned, liquid tight. Any leakage which might develop from the chambers to the back of element 15 is effectively prevented from egress by packing gland 20.

Now if the unit is assembled with the two chambers completely filled with a liquid such as oil and an oscillating torque is applied to shaft 21, by any suitable manner such as a crank shaft

and eccentric, there will be a pressure exerted on the ears 16 tending to rotate them slightly in groove 13 and oil will be forced from one side of the ears to the other through the apertures 17. The force required to accomplish this action will necessarily be transmitted to casing 12 and shaft 22 joined to the enlarged head 9 at the end of the torsion shaft 8, and its magnitude will be proportional to the size of the holes 17 and the viscosity of the oil being used. If the resistance offered to the rotation of shaft 22 is slight the angular velocity of shaft 21 will be transmitted practically undiminished to shaft 22, but if the resistance offered to the rotation, or oscillation, of shaft 22 is great, then oil will be forced through the holes 17 and a lesser velocity will be transmitted to shaft 22.

The method by which this mechanism can be used to advantage in the operation of the resonant doffer comb arrangement is shown in Figure 3 and can best be understood from the following description.

As an example, let us suppose that shaft 22 of the clutch mechanism shown in Figure 3 is energized by shaft 21 on the other end of the clutch and that shaft 21 is connected to a motor driven eccentric to oscillate shaft 21 through some angle about its axis corresponding to the desired angular amplitude of comb 5. In so doing comb assembly 5 will attempt to move at the same frequency and amplitude as shaft 21 is being driven, but by reference to Figure 5, it will be noted that the torque required to maintain a given angular amplitude at frequencies below the resonance point are very much greater than those required at resonance which is the low point of the curve of Figure 5. Therefore if the clutch were not provided the motor driving the eccentric connected to shaft 21 would have to provide a torque many times larger to start the comb in oscillation at the given angular amplitude than would be required to run it at resonance.

The advantage in the use of the mechanism shown at the left end of Figure 3 and in Figure 6, can therefore be appreciated. With the eccentric starting from a dead stop the torque required to maintain comb 5 in oscillation at a given angular amplitude of resonance may be greater than the motor can conveniently supply. When this occurs the pressure exerted on the oil by ears 16 causes oil to be forced through holes 17 and element 15 slips with respect to casing 12 thus reducing the angular motion of comb 5 and therefore reducing the torque required to oscillate it, and permits the motor to gain speed. As the motor driving the eccentric builds up in speed, so also does the comb and as the speed approaches resonance the torque required to drive comb 5 progressively reduces less and less, slip takes place between ears 16 and casing 12 until finally, at the resonance point the slip is substantially zero and the comb is being driven at the same angular amplitude as the eccentric.

By the above means the size of the motor required to start and run the comb may be very much less than would otherwise be the case.

The cross sectional area of the groove, the size of the hole in the ears, and the viscosity of the oil used are a matter of design. However, as an example I have found that using a groove $\frac{3}{8}$ inch square with the hole in the ears $\frac{1}{32}$ inch in diameter, and using oil of a viscosity of 20,000 centistokes, 170 watts can be transmitted with no appreciable slip at speeds in the neighborhood of 3600 vibrations per minute with an angular amplitude of the comb of .0803 radian corresponding to a stroke of $\frac{5}{8}$ inch at the comb oscillating about an axis 4 inches distant.

The amplitude of the comb throughout its length will be substantially uniform since the tube 7 is sufficiently rigid so that it will not have torsional displacement along its length that the balanced shaft 8 will have at the frequencies mentioned above.

Mention has been made above of the fact that I prefer to design the compensating inertia so that its inertia will equal the inertia of the comb-tube assembly and that under these circumstances the nodal point or point of zero angular displacement of the torsion shaft will occur in the middle. While this is generally true and offers a solution of the problem which is most economical of material the compensating inertia need not necessarily have the same inertia as the comb assembly. In fact in certain special cases it may be desirable to have them unequal.

As an example it might happen that for the angular amplitude desired at the comb the value of L as determined by the method described above might be such that using a counter-balancing inertia of the same value as that of the comb assembly would mean that the length of the torsion shaft 8 would be such that the combination would be too long for installation on the card with which it was intended to work. This difficulty may be overcome by using a counterbalancing inertia larger than that of the comb as will be understood from the following.

Earlier it was pointed out that the opposing torques at the nodal point must be equal and opposite. However, it will be noted from the equation determining the maximum accelerating torque required that this value is directly proportional to both the inertia and the maximum angular amplitude, for the same frequency. Therefore if the inertia of the counterbalancing inertia is increased and its angular amplitude reduced in the same proportion, then the torque remains constant and the criterion of equal and opposite torques at the nodal point is complied with. Under these circumstances it will also be obvious from the above and following equations that although the shaft diameter remains constant for the same fiber stress, its length in the case of the increased value of inertia in the counterbalancing inertia is reduced, and in the same proportion as the increase in the value of the inertia.

Thus, for instance, if the value of L for a given comb assembly, frequency, and angular amplitude, comes to 18 inches, and we use an equal inertia in the counterbalance, then its shaft length L' will be the same, making the overall length of the torsion shaft, 36 inches. If, however we design the counterbalance to have an inertia twice that of the comb assembly, it will oscillate at ½ the comb angular amplitude and its shaft length will then be 9 inches instead of 18 inches making the overall length of the torsion shaft 27 inches instead of 36 inches.

While there is no sharply defined line of division in operating speeds, I prefer to use the mechanically driven eccentric and clutch arrangement for providing the pulsating torque required for oscillating the comb at the lower speeds, say up to 3600 vibrations per minute. For higher speeds I prefer to use a different driving arrangement and also for the special cases of unequal inertias described above, both for higher and lower speeds. By higher speeds, I mean

speeds substantially above 3600 vibrations per minute, say 5000–7000 per minute.

The driving arrangement which I prefer to use for speeds above 3600 per minute, although it can be used with equal effectiveness at speeds of 3600 per minute or lower, is shown schematically in Figures 7 and 8, where respectively Figure 7 is a longitudinal section of the driving assembly and Figure 8 is a sectional view of the driving system.

Referring now to Figure 7, the comb-tube assembly is solidly secured to the further end (right end as viewed in Figure 3) of the torsion shaft **8**, in the drawing and the tube **7'** is free to move with respect to the torsion shaft **8** at its end section **9'** where because of its enlarged end it acts as a bearing to support the left end (as viewed in Figure 3) of the tube-comb assembly. The tube **7'** at its end, designated as **24**, has a shoulder with an extending neck on which the armature **24'** of a D. C. motor is mounted or formed and adapted to be rotated through at least a small angle with respect to the field structure **25**. This structure may be made to supply the necessary pulsating torque required to energize the system by furnishing direct current to the field windings **26** and supplying alternating current of the desired frequency of vibration of the comb, to the armature. However I prefer to connect the field and armature windings in series and then supply alternating current of one-half the desired frequency of vibration to the comb for reasons which will appear below.

First of all the use of such an arrangement eliminates the necessity for a separate D. C. exciting current for the field winding since a series connection of this sort would supply alternating current to both field and armature and results in pulses of torque being delivered by the "motor." Thus if alternating current at a given instant is such to make the two poles north as indicated by N in Figure 8, and the remaining two south, then with the current in the turns on the armature directly under the north poles flowing in a direction perpendicular to the end toward the plane of the paper, the armature would tend to turn in a direction counter-clockwise with respect to the pole pieces. The same would be true under the south poles because at the same instant both the flux in the south poles and the current in the windings under them would be flowing in the opposite direction to the flux in the north poles and the current in the windings under them.

This same condition would hold true when the direction of the flow of alternating current reverses at the next half cycle; there will again be a tendency for the armature to rotate in a counterclockwise direction with respect to the field. Thus since this condition occurs twice per cycle of the alternating current there will be two torque pulsations of the armature per cycle of alternating current with respect to the field.

It will also be noted from Figure 8 that the field laminations or elements **27** of the motor are bolted to a backing plate **28** which in turn is secured to the extension of the torsion shaft **8** by means of the key **29**. The inertia of this combination of field member **27** and backing member **28** are, in effect secured to one end of torsion shaft **8** and the comb-tube assembly is secured to the other end of torsion shaft **8**. Therefore when current is supplied to the series combination of armature and field, there will be a series

of torque impulses generated by the "motor" which tend to twist the two ends of torsion shaft **8** in opposite directions. If the frequency of alternating current supplied to the "motor" is chosen at half the frequency of the resonant system composed of the comb-tube assembly secured to one end of a torsion shaft and the inertia of the motor field and backing plate at the other, the "motor" will supply torque pulses to the resonant system at its own natural frequency. The resonant system comprises the masses and the torsional shaft to which the masses are attached which stores up the potential energy accounting for the forces opposing the torque pulse. The comb, tube and motor oscillate as a unit on the shaft bearing when the natural or resonant frequency of the system is attained.

Insofar as the angular amplitude of vibration of the comb is concerned, this is determined, in the case of the eccentric and clutch arrangement first described, by the eccentricity of the eccentric, and in the case of the electromagnetic drive just described, by the magnitude of the current supplied to the coils and armature of the driving system.

Having now described my invention, I claim:

1. A drive for a doffer comb of the type described including means providing a resonant torsional system having the doffer comb at least a portion of one of the masses thereof, means providing a second mass and a coupling means having a spring torsional shaft connecting said two masses.

2. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure forming a mass element of the resonant system, a torsional shaft forming the resonant coupling element for the doffer comb and structure attached at one end to said structure and means including in part an element providing a selected mass joined to the other end of said torsional shaft.

3. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure comprising an elongated tube for supporting said comb, a torsional shaft mounted coaxially within said tube and attached rigidly at one end to said tube, and means having a desired mass attached to the other end of the torsion shaft for establishing resonance to the system at the desired frequency and with the desired amplitude of oscillation.

4. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure comprising an elongated tube for supporting said comb, a torsional shaft mounted coaxially within said tube and attached rigidly at one end to said tube, with the other end free of the torsional shaft, and means having a desired mass attached to the other end of the torsion shaft for establishing resonance to the system at the desired frequency and with the desired amplitude of oscillation.

5. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure forming a mass element of the resonant system, a torsional shaft forming the resonant coupling element for the doffer comb and structure attached at one end to said structure, means including in part an element providing a selected mass joined to the other end

of said torsional shaft, and a slipping clutch means rigidly coupled to one end of the torsional shaft.

6. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure forming a mass element of the resonant system, a torsional shaft forming the resonant coupling element for the doffer comb and structure attached at one end to said structure, means including in part an element providing a selected mass joined to the other end of said torsional shaft and a slipping clutch means rigidly coupled to the end of the torsional shaft attached to said structure, and a slipping clutch means rigidly coupled to one end of the torsional shaft.

7. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure forming a mass element of the resonant system, a torsional shaft forming the resonant coupling element for the doffer comb and structure attached at one end to said structure, means including in part an element providing a selected mass joined to the other end of said torsional shaft and means for applying torsional motion between said other end of the torsional shaft and said structure.

8. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure comprising an elongated tube for supporting said comb, a torsional shaft mounted coaxially within said tube and attached rigidly at one end to said tube with the other end free of said torsional shaft, and means for providing torsional motion between the free ends of the tube and shaft including means providing a mass element for establishing desired resonance attached to said torsional shaft.

9. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure comprising an elongated tube for supporting said comb, a torsional shaft mounted coaxially within said tube having enlarged ends one of which is attached rigidly to said tube and the other serving as a free bearing for the tube and means adapted to apply torsional motion at the end of the tube to which the shaft is attached rigidly.

10. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure comprising an elongated tube for supporting said comb, a torsional shaft mounted coaxially within said tube having enlarged ends one of which is attached rigidly to said tube and the other serving as a free bearing for the tube and means adapted to apply torsional motion to one end of said torsional shaft.

11. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure forming a mass element of the resonant system, a torsional shaft forming the resonant coupling element for the doffer comb and structure attached at one end to said structure, means including in part an element providing a selected mass joined to the other end of said torsional shaft, and a slipping clutch means rigidly coupled to one end of the torsional shaft having a fluid chamber formed in an annular sector coaxially with the torsional shaft in one portion of the clutch with a close fitting projection having an opening there-through extending from the facing of the other portion of the clutch whereby fluid may be forced from one portion of the chamber to the other through said opening controlling the amount of slipping.

12. A drive for a doffer comb of the type described comprising a resonant torsional system having an elongated doffer comb and supporting structure comprising an elongated tube for supporting said comb, a torsional shaft mounted coaxially within said tube and attached rigidly at one end to said tube with the other end free of said torsional shaft, and means for providing torsional motion between the free ends of the tube and shaft including a field element of a motor attached to one of the free elements and an armature element attached to the other free element, both adapted to be energized by alternating current.

EDWARD W. SMITH.

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