Development of a retrofit mechanism for limiting vehicle speed

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ABSTRACT: A minimal death toll is yet to be associated with road as a means of transportation despite highway speed regulation policies embarked on by the Federal Government of Nigeria, since the mid-1980s. In an independent survey carried out, as preliminary part of this work, in one of the busiest interstate motor parks (Ojota Motor Park)in Lagos State, about 39.7% of vehicles in the park were carbureted and were reportedly driven instantaneously at speed over 120 km / hr on roads only safer for lower speeds. In the light of these findings, this paper develops a speed limiting mechanism for carbureted vehicles.

The mechanism has a throttle pedal connected to a carburetor throttle valve through a linkage. The mechanism includes a three link system and connecting means. An electromagnet is employed to hold the mechanism during driving at speed below a preset maximum speed. However, when the preset maximum limit is reached, the electromagnet is de-energized by a pnp transistor and a pivotal connection moves into a position which acts on the linkage connected to the carburetor throttle valve to move this throttle valve towards a closed position, hence, limiting the maximum speed of the vehicle.

With proper design values, finite element analysis tools would show that the linkage mechanism can open carburetor valve as the accelerator pedal is depressed; the electromagnetic field components can limit this opening, even against driver's desire. This mechanism can be researched into an efficient retrofit for limiting drive speed of owned vehicles.

Keywords: **Speed limiting device, linkage, mechanism, electromagnetic field components.**

1. INTRODUCTION

Road accidents over the years have been the commonest form of transportation accidents, and majority of such accidents have been attributed to over-speeding. Africa is one of the continents that have suffered great and incessant casualties. This is as a result of over speeding on dilapidated or never tarred roads. In many cases, motorists ignore the dangers that over-speeding pose to their safety and to those of others. Even with the several speed limit measures that are implemented in highways and other roads, so that motorists would be aware when they are driving at higher speeds, many commercial drivers are being seen nonchalantly disobeying these measures. This nonchalance is attributable to a combination of reasons: alcoholic effects, youthful exuberance, rush to return quickly on queue, indecorous commercial drivers' training and so on. Several reports on road related accidents have attributed lives and properties loss to high speed collisions [1-3]. [4] Jacobs et al reported that Nigeria has the highest rate of road accidents and the highest number of deaths per 10,000 vehicles in the world. [5] Nnabugwu, Daily Times Nigeria Newspaper Correspondence, in his 28th August, 2013 article reported that The Head (Policy, Research and Statistics Department) of the Federal Road Safety Corp (FRSC), Dr Kayode Olagunju confirmed Nigeria has one of the highest road traffic crash figures. The FRSC boss stated that in year 2012 alone, a total of 4260 deaths and 20752 injuries on Nigeria's roads were documented. Hence, on the average, 69 persons were either injured or killed daily; 48114 persons were involved in 6,269 documented cases.

Remarkably, and in consonance with the Nigeria's state, vehicular crashes are one of the leading causes of death in active adults in several other countries in Africa, Asia and Latin America [6]. [7] Atubi echoed this alarming rate in some Africa's countries; he reported that Nigeria leads 43 other nations with deaths in 10,000 vehicle crashes. Ethiopia ranked second with 219 deaths per 10,000 vehicles while Malawi and Ghana ranked third and fourth with 183 and 178 deaths respectively. [8] Atubi presented a wider international comparison on the number of road accidents vis-à-vis the number of death; while Czech Republic has only one death in 197 accidents, France one death in 175, South Africa, one death in 47 accidents, Nigeria has an alarming one death in about 3 recorded accident cases. High speed vehicular collisions will continue to be the leading cause of tragic accidents to commercial drivers and commuters on Nigeria's roads, if drivers, especially the younger folks, would not be cautious enough and place premium responses towards the need to stay alive while on the roads.

1.1 History of speed regulation

The phrase “speed kills” has been well known as a slogan and also supported by many researchers. The early framework for speed regulation was developed in the 1920s and 1930s in USA [9]. The national speed limit of 55mph was legislated in 1974 due to the energy crisis between 1973 and 1974, which resulted in a decline in freeway deaths per mile driven. However, in 1987 the 55mph limit was relaxed when the Surface Transportation and Uniform Relocation Assistance Act allowed individual states to raise their speed limits to 65mph on rural freeways.

Many studies on the effects of increased speed limit to fatal accidents have been carried out since then [10]. [11] Gallagher et al and [12] Brown et al analyzed the cause of fatalities in road accidents against the raised speed limit of 65mph and reported an 18% increase in fatal accidents in Alabama and 93% in New Mexico, both in the State. Also in tandem with reports of [11] and [12], the studies by [13] McKnight and Klein showed a 27% increase in fatalities on 65mph highways, and also a 10% increase in fatal accidents on 55mph highways in those states where the speed limits remained unchanged. [14] The National Highway Traffic Safety Administration concluded that the speed limit increase was responsible for a 30% increase in rural freeway fatalities in these states that adopted the higher speed limit. However, [15] Lave and Elias reported that the higher speed limit resulted in fewer fatalities. Due to these various findings, a question on whether the increased fatal accidents were purely and simply caused by the higher speed limit or a combination with other factors (such as increase in traffic volume, change of driving behaviors, etc.) remains unanswered. Notwithstanding, all opponents to higher speed limits have drawn on the “speed kills” hypothesis that assumes that higher speed reduces the amount of time a driver responds to an emergent event; speed regulation also relates to many social aspects including safety, journey time, energy efficiency, etc.

The findings from researches evaluating higher speed limits did not provide a clear indication as to which of these limits best describes the experience of the states [16]. In 1987, the American government revised its policy relating to the national speed limit and gave individual states the power to set their own speed limits. There were 39 states that adopted a 65mph speed limit and by the end of 1995, this number increased to 45. By the end of 1997, there were 27 states that raised their speed limits to at least 70mph – a reflection of the downward trend in road accidents and fatalities [17].

In effect, the downward trend in road traffic accidents in most developed states is largely attributed to a combination of interventions, strategies, policies and legislations that were developed over the past decades. Such factors as improved road networks, increased health budgets, sufficient accident scene analysis and documentation, high levels of health and safety awareness, are some of the interventions that yielded this downward trend [18]. Ironically, in Nigeria, studies have indicated that better facilities in terms of good quality and standardized roads have been accompanied by increasing number of accidents [2]. This is totally contrary to the trends in countries where even the level of sophisticated road network and volume of vehicular traffic are much higher.

Upon this back drop, it becomes so paramount, with urgency, to implement a legislation which supports the attachments or the devising of a vehicle maximum speed limiter into motor vehicles, which were originally designed for more advanced and accessible roads networks and safety-conscious drivers. This paper designs a maximum speed limiting mechanism based on a three linkage mechanism interconnecting a throttle pedal with a carburetor throttle plate for moving this throttle plate to a closed position when a preset maximum speed of a vehicle is exceeded.

2. MATERIALS AND METHODS

2.1 Design consideration of components

The mechanism for the demonstration of a carbureted vehicle speed limiter as proposed in this paper, simply replaces the conventional throttle cable by a linkage mechanism. That is, a small portion of the throttle cable attached to accelerator pedal 33 serves as the connecting cable between the throttle pedal and the first link 39 of the linkage mechanism. The speed limiting device components to be used shall be classed under mechanical and electrical components. The mechanical components entail those components that current do not flow through or have any potential differences across their ends. Components under this class include the linkage mechanism (link 39, link 40 and link 41), the tension spring 42 and spring 43, the connecting cable 36, the accelerator pedal 33 and the pivotal pins. The electrical components, on the other hand, encompass those components of the speed limiter that function based on potential differences or current flow between ends. The pnp transistor 30, electromagnet 53, relay 28, Bar Display System (represents the speedometer) and electrical cable are the basic electrical components required. The design considerations for the transistor, relay and speedometer are discussed in section 2.2, while the design of the electromagnet comes in the tail end of this section, section 2.4.

2.2 Design considerations for the electrical components

2.2.1 *Bar Display Speedometer, BDS:* The BDS consists of voltage divider and ten comparators for each chip (LM3914) with Light Emitting Diodes (LEDs) which serves as visual display. The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display, see Figure 1 below. The circuit contains its own adjustable reference and accurate 10-step voltage divider. The LM3914 is very easy to apply as an analog meter circuit. A 1.3V full scale meter requires only one resistor and a single 3-18 volts for power in addition to the 10 display LEDs. If the one resistor is a pot, it becomes the LEDs brightness control. However, this model cascaded two LM3914 (20 display LEDs) and thus the input voltage read out ranges from 0.13 to 2.6 volts, see Appendix C. The input voltage can be obtained from the voltage that drives the speedometer which acts as the input voltage for the circuit arrangement used in the BDS.

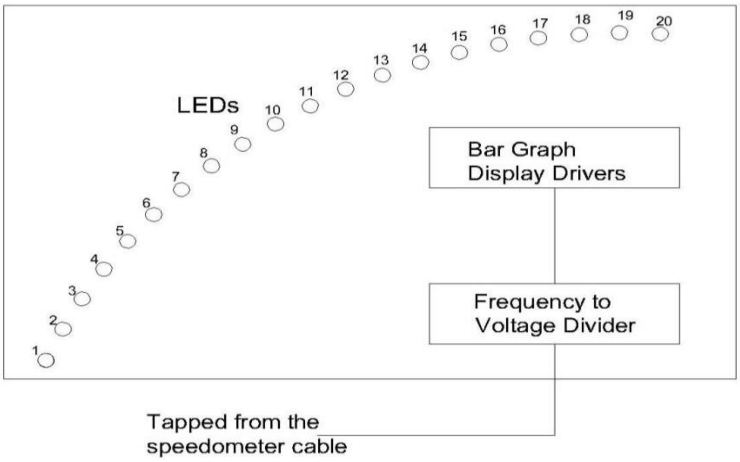

Figure 1: Analog Bar Display circuitry.

2.2.2 *Relays:* A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts [19]. The relay is employed to energize and de-energize an electromagnet 53 at a reference voltage corresponding to the maximum speed level. The other end of the winding 29 is connected to the positive terminal 25 of the source of electrical energy (12.0volts storage battery) through the normally closed switch, which is a transistor 30 shown in Figure 2. A low voltage relay, TS12A4516 will be employed to energize and de-energize the electromagnet 53.

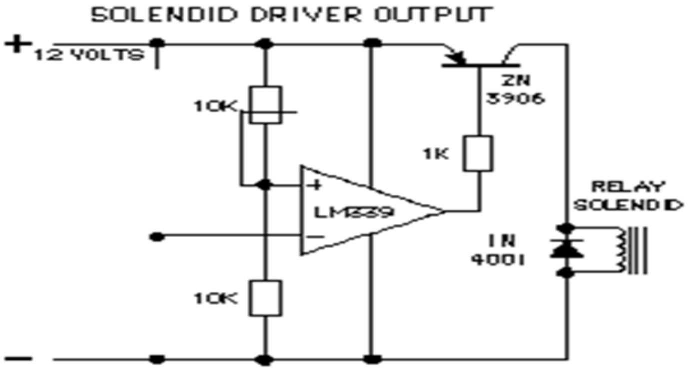

Figure 2: A circiut diagram of a circuit that will energise the soleniod of the relay.

2.2.3 *PNP transistor:* Transistors are generally three-terminal electronic devices constructed of doped semiconductor material used as switches and amplifiers. Referring to Figure 4, the solid state pnp transistor 30 has its emitter connected to ground through solenoid or winding 28 and lead 29, and its collector 56 connected to the dc storage 25 through lead 23 A transistor that can carry a current up to 10 ampere is used while a resistor will be used to give a forward bias to the transistor 30. This is necessary so as to withstand extremely high driving conditions. Transistors reliability becomes compromise at high temperatures if the current in flow is higher or close to the designed amperes.

2.2.4 *Battery*: The direct current source used in this model is a 12.0 volt storage battery **25**. This is used to power the transistor and the electromagnet.

2.3 Design of the Mechanical Components

2.3.1. *The linkage mechanism:* The links can all be made up of steel materials. The linkage mechanism helps in transmitting the required force to open the throttle valve 45 from the throttle pedal. The required force is the summation of the force required to open the carburetor valve to its full open state before it is coupled with the model, that is, the resistance F_C created by the valve spring and the force of transmission. The carburetor is mounted properly on a bench vice and the anchor end of a spring balance is hooked to the spring end of the valve to pull it. The spring balance reading F_C at the valve full open state is noted. However, this mechanism is designed to replace the conventional throttle cable that runs from the accelerator pedal 33 level to the throttle valve 45. Figure 3 shows the connecting linkage system.

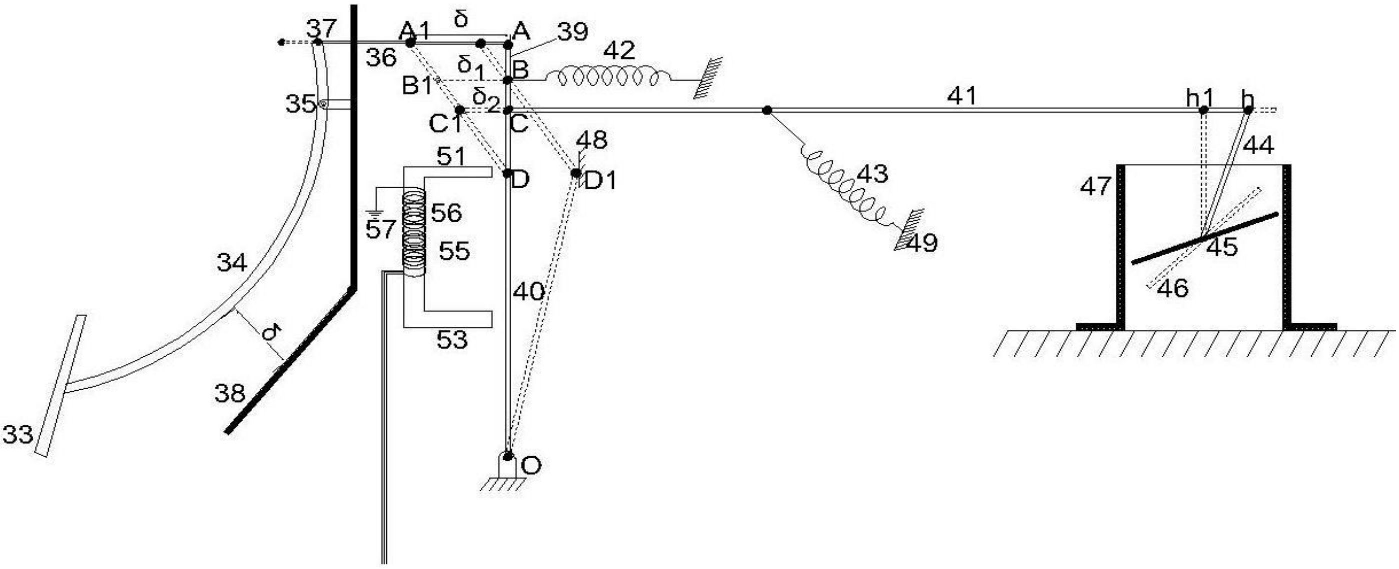

Figure 3: The control linkage between the accelerator pedal and the carburetor throttle in the speed limiting model.

Connecting cable 36: The linkage means 50 comprises a connecting means 36, which is connected at one end as shown at 37 to the end of arm 34 of the accelerator lever 34. The other end of the connecting means 36 is pivotally connected by pivotal connection A to one end of a first link 39. The traditional accelerator cable can be employed; an inspected accelerator cable of a vehicle has a diameter 5mm and Length of 300mm.

Link 39 (AD): Thus, area of link 39 is given as

$$A_1 = \frac{\pi D_1^2}{4} \quad \text{(Diameter, } D_1 = 10\text{mm, Length, } L_1 = 110\text{mm are selected for the link)}$$
$$= 8660.14\text{mm}^2$$

This link 39 anchors spring 42 and also holds one end of the connecting cable 36 from the throttle pedal arm 37. This link rotates counter clockwise about the pivotal connection D and link 40 as the accelerator pedal 33 is depressed.

Link 40 (DO): This link is designed to connect to the lower end of link 39 by a pivotal connection pin D and anchored at its other end E. The diameter of the link is taken to be equal to that of link 39, $D_2 = D_1$, with length $L_2 = 300$mm selected. This link 40 is maintained in a vertical position with the help of an electromagnetic 53. However, as the electromagnet 53 becomes de-energized, it rotates clockwise about its anchor E to the affixed abutment.

Link 41: This third link carries the throttle crank arm 44 that aids the opening and closing of the throttle plate 45. Similarly, the same diameter rod is used. The length of this link is the longest with length $L_3 = 533$mm selected. This link is biased to the right by spring 43, thereby biasing the throttle valve 45 to the closed position.

2.3.2 *Force, displacement and moment analysis:* The link mechanism which has been designed to replace the conventional accelerator cable is only effective when it can open the carburetor valve 45 to its full-open state at the accelerator pedal 33 lowest position, δ. Thus, the force required to open carburetor valve 45 to its full open state is required. Carburetor valve

45 is normally controlled by a spring which opposes the opening of the valve. This force varies within the same model of vehicles and differs from brand to brand. Also the accelerator pedal lowest position δ relative to the vehicle floor varies for vehicles, this value is measured. It represents the farthest distance the first link 39 can travel to the left about pivotal connection D under the accelerator pedal force, F_P.

Let the force required to open the carburetor valve 45 to its full open state be F_C

If the force required at the accelerator pedal is F_P, thus, $F_P > F_C$ since some forces would be overcome by F_P for F_C to be available for the opening of the carburetor, these are:

(i) the weight of the accelerator pedal, W_P;
(ii) the weight of the linkage rods; and W_L;
(iii) the resistive effect of the two tensional springs, spring **42** and 4**3**, F_S

Thus,

$$F_P = F_C + W_P + W_L + F_S \qquad \text{...(i)}$$

The following assumptions are embodied in this design:

(i) All pivotal pin connections are frictionless.
(ii) All vertical components of forces are negligible since mechanism is intended to only transverse horizontally
(iii) The weight of the mechanism is neglected
(iv) The weight of the accelerator pedal is neglected

Considering the free body diagram of the mechanism**,** Figure 4 below

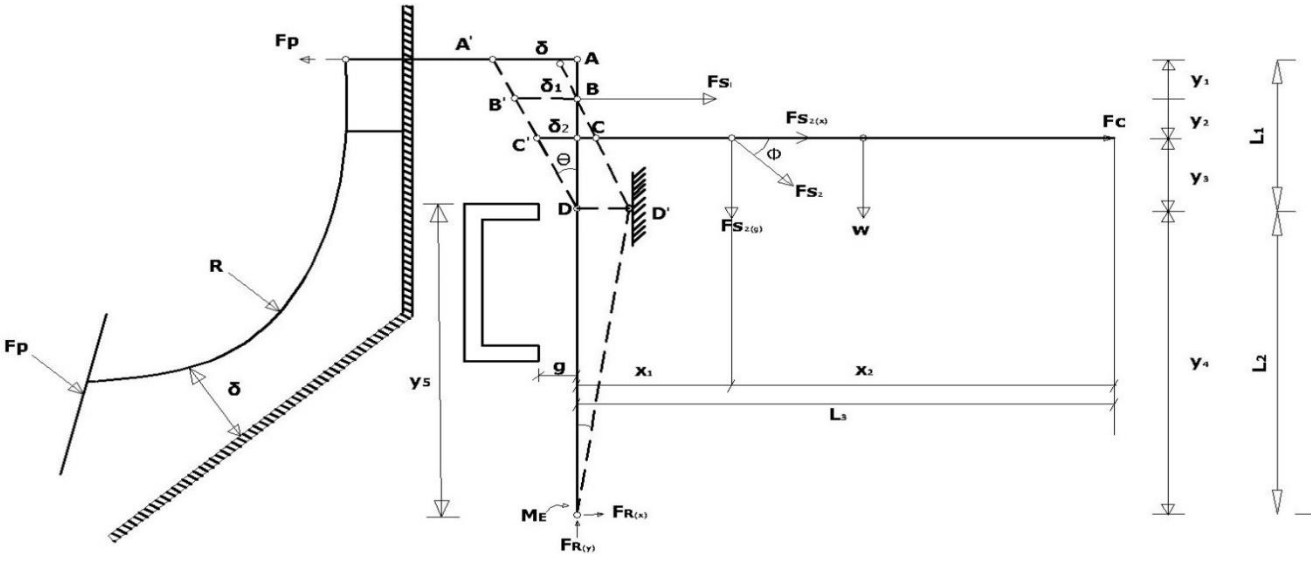

Figure 4: Free body diagram of mechanism.

δ represents the lowest position relative to the vehicle floor the pedal can cover (to be measured)
δ_1 represents the deflection experienced by spring 42
δ_2 represents a component of the deflection experienced by spring 43
F_{S1} represents the resistive force by spring 42 to the accelerator pedal force F_P
F_{S2} represents the resistive force by spring 43 to the accelerator pedal force F_P
However, F_{S2} is acting at an angle of φ to the horizontal; hence

$$\cos\varphi = \frac{F_{S2(x)}}{F_{S2}} \qquad \text{...(ii)}$$

$$F_{S2}\cos\varphi = F_{S2(x)} \qquad \text{...(iii)}$$

$F_{S2} \sin \varphi = F_{S2(y)}$ ...(iv)

The calculation of δ_1 and δ_2 can be done using simple trigonometry analyses: See Appendix A

From equation (i)

$F_P = F_C + W_P + W_L + F_S$

W_P and W_L are assumed negligible

Therefore, Equation (i) becomes

$F_P = F_C + F_S$ ...(v)

$F_P - F_C = F_S$ ...(vi)

Gives the force that both springs can withstand without braking;
Using a simple bench test, a spring balance hooked to a carburetor control valve can be used to determine the force needed to fully open its valve. For a tested carburetor; $F_C = 16N$

$F_P - 16 = F_S$

Taking a value of 20N for F_P
Hence, $F_S = 4.0N$; $F_{S1} + F_{S2} = 4.0N$ ... (vii)

Using the same material type and grade for the two springs, then for the two springs are in parallel

$4.0 = K_1\delta_1 + K_2\delta_2$ ...(viii)

Where $K_1 = K_2 = K$ is the spring stiffness. $K = 4 \times 10^{-2}N/mm$, for values of $\delta_1 = 60mm$ and $\delta_2 = 40mm$
Thus, the resistive force of spring 42, $F_{S1} = 2.4N$ and that of spring 43, $F_{S2} = 1.6N$.
All vertical components of all forces have been neglected since the linkage mechanism only moves in the horizontal direction.

Hence, input parameter values needed for the design of the two tension springs are

(1) Maximum loads are 2.4N and 1.6N for spring 42 and spring 43 respectively
(2) Maximum deflections are 60mm and 40mm for spring 42 and 43 respectively
(3) Both ends of both springs are looped. In [20] Khurmi and Gupta, the number of turns $n^1 = n + 1$
Where, n = Number of active turns.
(4) Material of spring to be used is Music wire ASTM A228.
(5) Recommended working temperature 120^0C (max)

Design equations used for springs [20]

(i) The relationship between load and deflection is given by

$$F = \frac{Gd^4\delta}{8D^3n} \quad \text{... (ix)}$$

(ii) Shear stress is given by

$$\tau = \pm\frac{8FD}{\pi d^3} + \frac{4F}{\pi d^2} \quad \text{... (x)}$$

(iii) Free length of the spring: Is the length of the spring in the free or unstressed condition. The length of tension spring having loop on both ends, L_F is given as;

$L_F = n.d. + (n - 1)$ ... (xi)

(iv) Pitch of coil used: The pitch of the coil is defined as the axial distance between adjacent coils in unstressed state. It is given as

$$p = \frac{L_F}{n-1} \quad \text{... (xii)}$$

Where
G = Modulus of Rigidity ($80 \times 10^3 N/mm^2$)

d = Diameter of spring wire
D = Diameter of spring coil
n = Number of active coil
C = Spring index (C = D/d),

Thus, choosing a value of 10 for the spring index, equation (v) becomes

$$d = n\left(\frac{8FC^3}{G\delta}\right) \qquad \text{... (xiii)}$$

More so, for a tension spring design (with minimum gap between the two coils taken as 1mm in its free state) the free length, L_f is given as;

$$L_F = n.d + (n - 1) \qquad \text{... (xiv)}$$

Using a spring of free length of 45mm

$$d = \frac{46}{n} - 1 \qquad \text{... (xv)}$$

Equating (xiii) and (xv)

$$d = n\left(\frac{8FC^3}{G\delta}\right) = \frac{46}{n} - 1$$

$$46 - n = n^2\left(\frac{8FC^3}{G\delta}\right) \qquad \text{... (xvi)}$$

is used to determine the active number of turns for the intended tension springs

For spring 42,

$$0 = n^2\left(\frac{8x2.4x10^3}{80x1000x60}\right) + n - 46 \qquad \text{... (xvii)}$$

This factorizes out into n = 40 turns and thus, d = 0.15mm.
Thus, diameter of coil,
D = C.d = 1.5mm.
Outside diameter of coil,
D_o = D + d = 1.65mm
Inside diameter of coil,
D_i = D – d = 1.35mm

From tension spring datasheet in [20] a standard wire of size SWG 38 having diameter of 0.1524 can be used.
Thus the pitch of coil is

$$p = \frac{L_F}{n-1} = 1.154\text{mm}$$

However, the two terms in equation (x) for shear stress can be combined by introducing a shear stress correction factor
K_S = (2C+1) / 2C (See Appendix B)
This gives,
$\tau = K_s\,(8FD / \pi d^3)$

But, K_S = 1.05 and thus, τ =2851.687N/mm^2
This gives the maximum allowable shear stress on spring 42.

For string 43
F = F_{S2} = 1.6N
C = 10
G = 80 x 10^3 N/mm^2
δ_3 = 40mm

Substituting equation (xvi) above

$$0 = n^2\left(\frac{8x1.6x10^3}{80x1000x40}\right) + n - 46$$

Similar to the equation used in getting the active number of turns of spring **42**. This is expected as both springs are made of the same material, equal spring index, equal spring stiffness constant. However, the shear stress differs owing to differences in working loads and expected deflections. Hence, allowable shear stress on spring **43** is given as

$\tau = 1901.124 N/mm^2$

In summary, Table 1 shows spring parameter values.

Table 1: Springs design values

Parameter	**Spring 42**	**Spring 43**
Wire diameter, d	0.15mm	0.15mm
Outside diameter of coil, D_0	1.65mm	1.65mm
Inside diameter of coil, D_i	1.35mm	1.35mm
Spring Index, C	10	10
Free length inside ends, LF	45mm	45mm
Pitch, p	1.154mm	1.154mm
Number of Active turns of coil, n	40	40
Maximum Expected deflection δ	60mm	40mm
Working load, F	2.4N	1.6N
Maximum allowable shear stress, τ	2851.687N/mm^2	1901.124N/mm^2

2.4 Design consideration of the U-shaped Electromagnet

In [21] Sharma, electromagnetism is defined as the relationship between magnetism and electricity. The phenomena of magnetism and electromagnetism are dependent upon a certain property of the medium called its permeability, μ. The electromagnet 53 is employed to keep link 40 and the pivotal connection D in vertical position during normal driving, that is, at driving speed below the preset maximum speed value. However, it is designed to lose the needed magnetic pull at the preset maximum speed, that is, at the reference voltage as used in this mechanism. Procedures and winding considerations for coiling an electromagnet is stated in [21].

The electromagnet 53 core can be made of silicon steel metal. The relative permeability of silicon steel, μ_r, is given as 40000 in [20]

Considering moment about the anchor, point E, in Figure 4

$$-F_E \times L_2 + 1.6(1/2 x L_1 + L_2) + 2.4(3/4 x L_1 + L_2) = 0 \quad ...(xviii)$$

$F_E = 4.867$ defines the combined pull of the magnet poles

Therefore, force per pole, F = 2.433N.

In [22] Theraja and Theraja, the lifting pull F of an electromagnet is given as

$$F = \frac{B^2 A}{2\mu_o \mu_r} \quad ... (xix)$$

Where, B = flux density

A = area of magnetic core, $2x10^{-4}$ m^2 would be considered

μ_o = permeability of free space, $4\pi x10^{-7}$

μ_r = permeability of silicon steel would be considered, 40000

Thus, Flux density, B = 34.72T, and given that magnetic field strength,

$$H = \frac{B}{\mu_o \mu_r} \quad ...(xx)$$

Thus, a magnetic field strength, H, of 696 Amperes - turn per metres is obtainable

also, $H.g = N.I$ ...(xxi)

N and I are defined as the number of turns and current to be carried by coil, respectively. g is the air gap between poles and link 40, and total air gap is 2g.

$$N.I = H.2g \quad ...(xxii)$$

with a design value of 20mm for g, the product N.I obtains a value of 27.84 Amp-turns

Choosing a current of 328mA, the number of turns to be made with SWG 26 of a copper enamel coil is,

N = 85, approximate number of turns
SWG 26 corresponds to coil of diameter 0.457mm [23]

In conclusion, the electromagnetic core could be wound with a copper enamel wire of diameter 0.457mm (SWG 26) with 85 turns in other to generate a pull of 4.867N on the link **40** at both poles.

3 RESULTS AND DISCUSSION

3.1 Discussion: Operation

With the mechanism at the rest position and the ignition switch of the vehicle open (the vehicle pedal un-depressed), the tension spring 43 connected to link 41 will move this link to the right and thereby cause crank arm 44 to move the throttle plate or valve 45 to the closed position. This action will anchor the pivotal connection D that connects link 40 to the first link 39. Consequently, auxiliary tension spring 42 will rotate link 39 clockwise about the pivotal connection C and thereby move the pivotal connection D and the link 40 into the position shown in the solid lines in Figure 3. In this position, the body of the link 40 is positioned closely adjacent the legs 51 and 53 of yoke of the electromagnet 53.

When the ignition switch (tuning of the Bar Display Speedometer pot of the model) of the vehicle is closed so that transistor 30 shown in Figure 5 is energized, the transistor 30 will be switched to a conducting state thereby energizing the solenoid or winding 28. Energization of the solenoid will move the armature of relay 60 into the closed position thereby energizing the winding 55 of electromagnet 53 from the source of electrical energy 25. Energization of the winding 55 creates a magnetic field through the yoke to thereby maintain the second link 40 in the position shown in Figure 5 and maintain the pivotal connection D between the link 39 and the link 40 in the solid line position.

When the accelerator pedal 33 is depressed, the arm 37 of accelerator lever 34 is moved counterclockwise and to the left thereby moving the pivotal connection A to the left and rotating the first link 39 counterclockwise about the pivotal connection D. This action moves the pivotal connection C between the link 41 and the first link 39 to the left and thereby opening the throttle plate or valve 45. This action is shown by the dotted line position of the accelerator lever 34 and the linkage 50. Thus, during normal vehicle operation, movement of the accelerator pedal 33 will pivot first link 39 about the pivotal connection D from the solid line position shown in the figure to control the opening and closing movement of the throttle plate or valve 45.

Should the vehicle operator continue to increase the speed of the vehicle (increase in voltage input into the Bar Display Speedometer) until the predetermined speed level (referenced voltage is reached), transistor 30 would be grounded. This action transients transistor 30 to a non-conducting state. As a result, the solenoid 28 of the relay is de-energized and the armature 60 of this relay is de-energized and the armature 60 of this relay moves to the open position. This action disconnects the winding 55 of electromagnet 53 from the source of electrical energy 25, thereby reducing substantially the magnetic field in the yoke which previously had been employed to hold the second link 40 and the pivotal connection D in the solid line position. At this time, the action of the tension springs 42 and 43 will move the pivotal connection D and the first link 39 to the right so that the pivotal connection D rotates with link 40 about the pivotal anchor E.

It can be readily appreciated that the movement of the pivotal connection D to the right will move the pivotal connection C to the right, and into the second or right hand dotted line position. Consequently, the pivotal connection h is moved to the right and throttle plate 45 is moved toward the closed position, thereby reducing the fuel flow rate getting into the combustion chamber. Invariably, the speed of the automotive vehicle falls below the predetermined speed level, that is, below the referenced voltage.

When the voltage is reduced below the predetermined speed level voltage, the transistor 30 comes off the grounding and thereby switching back to a conducting state and re-energizing solenoid or winding 28 of the relay. This action will move the armature 60 into its closed position thereby re-energizing the winding 55 of the electromagnet 53. Consequently, the vehicle operator cannot increase the speed of the vehicle further, that is, the force on the pedal must be removed. He may only reestablish the normally operating position of the linkage by releasing the pressure on the accelerator pedal 33. When he does this, the throttle plate or valve 45 is moved to the closed position and the tension spring 42 acts to rotate the first link 39 clockwise about the pivotal connection C between this first link 39 and the link 41. Consequently, the second link 40 and the pivotal connection D is rotated counterclockwise about the pivotal anchor E back into the solid line position and the linkage is returned to its normal operating position.

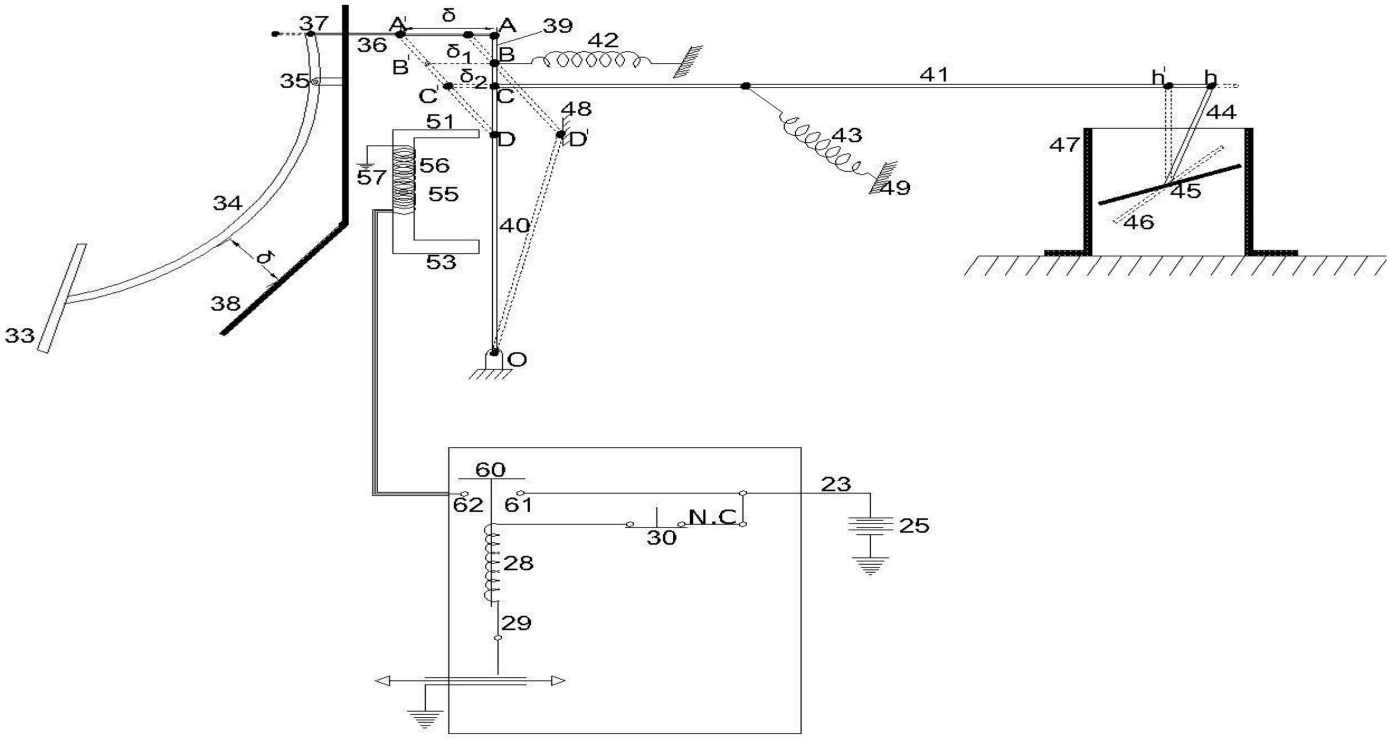

Figure 5: The model schematic showing the linkage mechanism and the electrical connection.

4. CONCLUSION AND RECOMMENDATIONS

With proper selection of the design values vis -a viz materials types, finite element analysis tools would show that the linkage mechanism can open the throttle valve of the carburetor as the accelerator is depressed; the electromagnetic field components can limits this opening, even against the driver's desire. This mechanism can actually be researched into an auxiliary speed limiter to be retrofitted into owned vehicles. Designing a tampered-proof system on the mechanism is of essence to deter unauthorized access.

The governments of countries - where loss of lives and properties are on the increase due to high speed vehicular crashes - can limit the speed at which vehicles are driven by flagging a "SPEED KILLS, KILL THE SPEED!" campaign. With this campaign in place, this design can be researched into a retrofit for existing vehicles in a way that the preset maximum speeds vary based on the vehicle classification (heavy, medium, and light duties); lower and safer drive speed limits are selected. The fatalities and occurrences of accident resulting from over-speeding won't only be immensely checked, human resources and properties would have been conserved.

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APPENDICES

Appendix A: From ΔADA^1, $\tan\theta = \frac{80}{110}$, thus $\theta = 36.03°$

Similarly, $\tan\theta = \frac{\delta_1}{82.5}$, thus $\delta_1 = 60$mm (with y_1 selected as 27.5mm)

Also, $\tan\theta = \frac{\delta_2}{55}$, thus $\delta_2 = 40$mm (with y_3 selected as 55mm)

Appendix B: The shear stress equation for helical springs is given as:

$$\tau = \frac{8FD}{\pi d^3} + \frac{4F}{\pi d^2}$$

$$\tau = \frac{8FD}{\pi d^3}\left[1 + \frac{d}{2D}\right]$$

$$\tau = \frac{8FD}{\pi d^3}\left[1 + \frac{1}{2C}\right]$$

$$\tau = \frac{8FD}{\pi d^3}\left[\frac{2C+1}{2C}\right]$$

$K_s = \frac{2C+1}{2C}$ is known as the shear stress factor and is a function of the spring index, C.

Appendix C: Circuit diagram of a Bar Display System

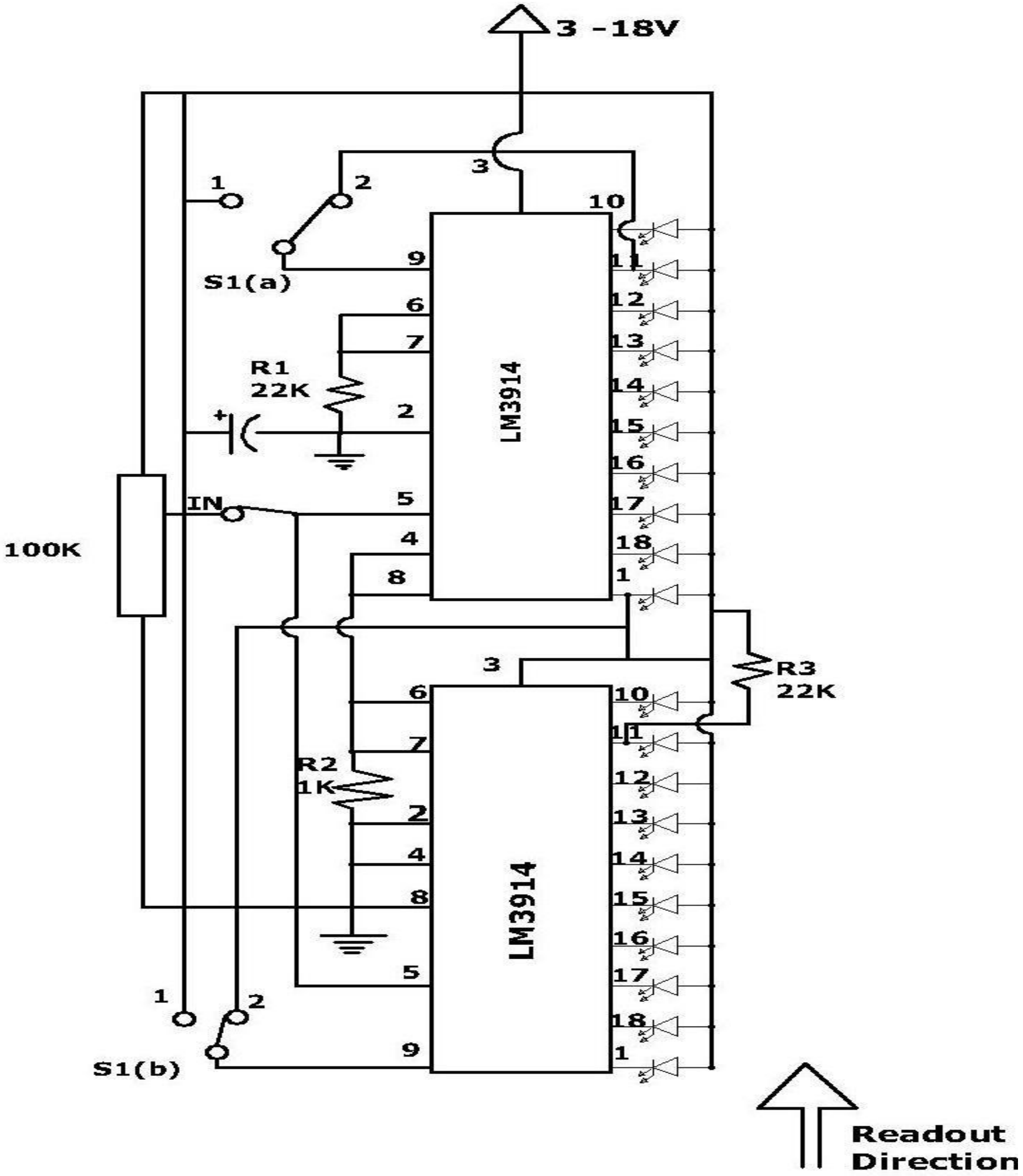

Figure 6: Circuit diagram of a Bar Display System.