Swing-Arms and Torsion Bars for Heavy Russian Motorcycles with Sidecars

• Heavy Russian Motorcycle Rear-Wheel Swing-Arm Suspension
  – Historical Evolution of Rear-Wheel Suspension
  – Rear-Wheel Plunger Suspension
  – Rear-Wheel Swing-Arm Suspension
    • One-Wheel Drive (1WD)
      – Rear-Drive Swing-Arm
    • Two-Wheel Drive (2WD)
      – Rear-Drive Swing-Arm
  – Not Covered: Front-Wheel Suspension Torsion Bar

• Sidecar Frames and Suspension Systems
  – Historical Evolution of Sidecar Suspension
  – Sidecar Rubber Bumper and Leaf-Spring Suspension
  – Sidecar Torsion Bar Suspension
  – Sidecar Swing-Arm Suspension

• Recent Advances in Ural Suspension Systems
  – 2006: Nylock Nuts Used to Secure Final Drive to Swing-Arm
  – 2007: Bottom-Out Travel Limiter on Sidecar Swing-Arm
  – 2008: Ball Bearings Replace Silent-Block Bushings in Both Front and Rear Swing-Arms

Heavy Russian motorcycle suspension started with the plunger (coiled spring) rear-wheel suspension on the M-72. This was replaced with the swing-arm (pendulum) and dual hydraulic shock absorbers on the K-750. Similarly the sidecar suspension was upgraded from the spring-leaf to rubber isolators and a swing-arm approach in the M-72M.
Not Covered: Front-Wheel Torsion Bar
History of Rear-Wheel and Sidecar Wheel Suspension

- Rear-Wheel Suspension
  - Original M-72 Suspension
    - Plunger (Coiled-Spring) Rear-Wheel Suspension
    - Ural’s M-61 and M-62 Also Used Plunger Suspension System
  - Upgrades to Rear-Wheel Suspension
    - In 1958/9 Dnepr (KMZ) Introduced K-750, New Frame with Pendulum (Swing-Arm) Rear-Wheel Suspension and Coil-Spring Shock Absorbers
    - In 1965 Ural (IMZ) Introduced M-63 (Ural-2), M-66, M-67 and 8-103.10 which Transitioned from So-Called Candle-Frame of M-72/M-61/M-62 to New Bike Frame with Swing-Arm, Pendulum Rear-Wheel Suspension and Hydraulic Shock Absorbers

- Sidecar-Wheel Suspension
  - Original M-72 Sidecar Suspension
    - Steel Leaf Springs
    - Until 1947, IMZ Did Not Let Sidecar Design Out of Gorky Plant
    - Later Ural and Dnepr Used Swing-Arm Suspension and Rubber Blocks, Replacing Leaf-Springs
  - In 1955 Ural (IMZ) Introduced M-72M with Sidecar-Wheel Torsion Bar Suspension
    - Retained Steel Leaf-Springs
    - Torsion Bar Mounted in Rear Cross-Member of Sidecar Frame
    - M-72M, M-61, M-62 Had Torsion Bar on Sidecar
    - Chinese-Built CJ750 (copy of M-72M) Has Torsion Bar Suspension
      - Has Both Leaf-Springs and Torsion Bar
  - In 1968/70 Ural (IMZ) Introduced M-63 (Ural-2), which Transitioned from Steel Leaf-Springs of M-72/M-61/M-62 to New Sidecar Frame with Swing-Arm, Pendulum Sidecar-Wheel Suspension and Hydraulic Shock Absorbers
Heavy Russian motorcycle production began with the plunger rear-wheel and spring-leaf sidecar suspension. Demands for operation on rough roads gave rise to swing-arms on both the rear-wheel and sidecar-wheel.
<table>
<thead>
<tr>
<th>Ural (Урал) Model</th>
<th>Production</th>
<th>Drive Train</th>
<th>Rear-Wheel Suspension</th>
<th>Rear-Wheel Swing-Arm</th>
<th>Sidecar Torsion Bar</th>
<th>Sidecar Swing-Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-72</td>
<td>1941-1950</td>
<td>Straight Final Drive (1WD)</td>
<td>Plunger</td>
<td>None (Plunger)</td>
<td>None</td>
<td>None</td>
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<tr>
<td>M-72K</td>
<td>1952-1958</td>
<td>Straight Final Drive (1WD)</td>
<td>Plunger</td>
<td>None (Plunger)</td>
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<td>None</td>
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<td>M-72M</td>
<td>1956-1960</td>
<td>Straight Final Drive (1WD)</td>
<td>Plunger</td>
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<td>M-61</td>
<td>1958-1961</td>
<td>Straight Final Drive (1WD)</td>
<td>Plunger</td>
<td>None (Plunger)</td>
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<tr>
<td>M-62 (Ural-1)</td>
<td>1961-1965</td>
<td>Straight Final Drive (1WD)</td>
<td>Plunger</td>
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<tr>
<td>M-63 (Ural-2)</td>
<td>1965-1971</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>6309080-Б</td>
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<td>M-66 (Ural-3)</td>
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<td>Straight Final Drive (1WD)</td>
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<tr>
<td>M-67 (IMZ-8.101)</td>
<td>1974-1976</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
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<tr>
<td>M-67.36</td>
<td>1976-1983</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>6309080-Б</td>
<td>None</td>
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<tr>
<td>8.103 Series “650” 1WD</td>
<td>1984-2002</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>IMZ-8.103-09081</td>
<td>None</td>
<td>IMZ-8.103-20019-20</td>
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<tr>
<td>“750”Series 1WD</td>
<td>2003-Present</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>IMZ-8.103-09081</td>
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<td>IMZ-8.1037-20019-01</td>
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<td>Dnepr (Днепр) Model</td>
<td>Production</td>
<td>Drive Chain</td>
<td>Rear Suspension</td>
<td>Rear Swing-Arm</td>
<td>Sidecar Torsion Bar</td>
<td>Sidecar Swing-Arm</td>
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<tr>
<td>M-72</td>
<td>1951-1956</td>
<td>Straight Final Drive (1WD)</td>
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<td>None (Plunger)</td>
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<td>M-72N (Н)</td>
<td>1956-1960</td>
<td>Straight Final Drive (1WD)</td>
<td>Plunger</td>
<td>None (Plunger)</td>
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<tr>
<td>K-750</td>
<td>1959-1963</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>5309200</td>
<td>7220227</td>
<td>650202-Б</td>
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<tr>
<td>K-750M</td>
<td>1963-1977</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>5309200</td>
<td>7220227</td>
<td>650202-Б</td>
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<tr>
<td>MT-12 (Dnepr-12)</td>
<td>1974-1982</td>
<td>2WD with Non-Locking Differential</td>
<td>Swing-Arm</td>
<td>ВП09800</td>
<td>None</td>
<td>ВП50510</td>
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<tr>
<td>MB-750</td>
<td>1964-1973</td>
<td>2WD with Locking (Engagable) Diff</td>
<td>Swing-Arm</td>
<td>ВП09800</td>
<td>None</td>
<td>ВП50510</td>
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<tr>
<td>MB-750M</td>
<td>1973-1977</td>
<td>2WD with Locking (Engagable) Diff</td>
<td>Swing-Arm</td>
<td>ВП09800</td>
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<tr>
<td>K-650/MT-8</td>
<td>1967-1971</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>65009200</td>
<td>None</td>
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<td>K-650/MT-9</td>
<td>1971-1976</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>65009200</td>
<td>None</td>
<td>650202-8Б</td>
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<tr>
<td>MB-650</td>
<td>1968-1984</td>
<td>2WD with Locking Differential</td>
<td>Swing-Arm</td>
<td>ВП09800</td>
<td>None</td>
<td>ВП50510</td>
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<tr>
<td>MB-650M</td>
<td>1985-1991</td>
<td>2WD with Non-Locking Differential</td>
<td>Swing-Arm</td>
<td>ВП09800</td>
<td>None</td>
<td>ВП50510</td>
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<tr>
<td>MT-10</td>
<td>1973-1976</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>65009200</td>
<td>None</td>
<td>650202-8Б</td>
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<tr>
<td>MT-10.36</td>
<td>1976-1984</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>65009200</td>
<td>None</td>
<td>650202-8Б</td>
</tr>
<tr>
<td>MT-11 (Dnepr-11)</td>
<td>1985-1995</td>
<td>Straight Final Drive (1WD)</td>
<td>Swing-Arm</td>
<td>65009200</td>
<td>None</td>
<td>КМЗ-8.15720200</td>
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<tr>
<td>MT-16 (Dnepr-16)</td>
<td>1986-1995</td>
<td>2WD with Non-Locking Differential</td>
<td>Swing-Arm</td>
<td>ВП09800</td>
<td>None</td>
<td>ВП50510</td>
</tr>
</tbody>
</table>
**Early Rear-Wheel Swing-Arm Suspension**

- Every Ural and Dnepr has Swing-Arm Suspension with Spring-Hydraulic Shock Absorbers
  - Except for M-72, M-61 and M-62, with Rear-Wheel Plunger (Coil-Spring) Suspension
  - In 1959 the Dnepr K-750 appeared, losing the old plunger frame design in favor of a Swing-Arm design, giving more suspension travel and a better ride over rough terrain.

<table>
<thead>
<tr>
<th>Motorcycle (Factory)</th>
<th>Suspension Type</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-72 (IMZ, KMZ)</td>
<td>Plunger</td>
<td>1941-1956</td>
</tr>
<tr>
<td>M-72K (IMZ)</td>
<td>Plunger</td>
<td>1954-1960</td>
</tr>
<tr>
<td>M-72M (IMZ)</td>
<td>Plunger</td>
<td>1956-1960</td>
</tr>
<tr>
<td>M-72N (KMZ)</td>
<td>Plunger</td>
<td>1956-1959</td>
</tr>
<tr>
<td>K-750 (KMZ)</td>
<td>Swing-Arm</td>
<td>1959-1963</td>
</tr>
<tr>
<td>K-750M (KMZ)</td>
<td>Swing-Arm</td>
<td>1963-1977</td>
</tr>
<tr>
<td>Ural M-61 (IMZ)</td>
<td>Plunger</td>
<td>1958-1961</td>
</tr>
<tr>
<td>Ural M-63 (IMZ)</td>
<td>Swing-Arm</td>
<td>1965-1971</td>
</tr>
</tbody>
</table>

M-72 pioneered the plunger (coiled-spring) suspension, which was replaced in the K-750. Ural’s M-61 and M-62 also used the plunger suspension system.
The M-72 had a plunger (coiled-spring) rear-wheel suspension.
Evolution from Plunger (M-72) to Swing-Arm (K-750) Rear-Wheel Suspension

Plunger (Coiled-Spring) Suspension

Swing-Arm Suspension with Spring/Hydraulic Shocks
Nearly all sidecars from the war vintage M-72 production have a rigid wheel suspension for the sidecar, as seen by a frame loop going over the top of the sidecar fender. This was also used on Chang Jiangs to about 1970, when they added a torsion bar suspension.
Torsion Bar Suspension

• Torsion Bar Suspension, a.k.a. Torsion Spring Suspension, Uses a Torsion Bar as Its Main Weight-Bearing Spring
• Torsion Bar, the Elastic Absorber, Is a Metal Rod with Circular Splined Ends
  – One End Is Firmly Attached to the Sidecar Chassis
  – Opposite End Terminates in a Lever, Mounted Perpendicular to the Torsion Bar, that Is Attached to a Suspension Arm, Spindle or Axle (Rocker Arm)
• Vertical Motion of Sidecar Wheel Causes the Torsion Bar to Twist around Its Axis and Is Resisted by the Bar's Torsion Resistance, thus Achieving Elastic Coupling between the Sidecar Wheel and the Sidecar Body
• Torsion Feature Is that Rotation in Only One Direction - Towards Twisting
• Effective Spring Rate of the Torsion Bar Determined by Its Length, Shape, Material, Cross-Section and Manufacturing Process
• Another Feature: Torsion Bar Can Be Used to Adjust the Height of the Sidecar
Sidecar Frames, Leaf-Springs and Torsion Bars

- Sidecar Frame Has Rigid, Reinforced, Double-Frame, Welded Tubular Construction
- Rectangular Frame Connected to Ball Clamps (3,23) and Two Adjustable Tie-Rods (9, 37)
- Brackets Welded at Rear of Sidecar Frame for Quarter-Elliptic Steel Leaf-Springs
- Sidecar Frame (11) Connected to Torsion Bar Suspension

1. Motorcycle Frame
3. Front Collet Chuck
4. Bolt Collet Fitting
9. Rear Tie-Rod Mounting Bar
11. Sidecar Frame
12. Spring
13. Spring Ladder
14. Lever Axle
15. Sidecar Wheel Axle
16. Wheel Protective Cap
22. Shoe Springs
23. Rear Collet Chuck
24. Idler Arm Rear Suspension
36. Adjusting Fork Rod
37. Front Tie-Rod Mounting Bar

Torsion Bar Suspension of Sidecar-Wheel

Ural M-63

Sidecar Wheel Axle
Ural (IMZ) introduced the torsion bar on the sidecar with the M-72M. It continued with the torsion bar from 1955 to 1965 with the M-61 and M-62, abandoning it with the M-63 with swing-arm sidecar suspension.
K-750, M-61 and M-62 Sidecar-Wheel Torsion Bar

- Torsion Bar Suspension Consists of Torsion Shaft (Bar, Rod) Made of Special Spring Steel and Mounted Across the Sidecar Frame
- Torsion Wheel Suspension Mounted in Rear Cross Tube (4) of Sidecar Frame
- One End of Torsion Bar (5) Rigidly Fixed to Sidecar Frame
- Other End of Torsion Bar Fastened to Axis of Sidecar-Wheel Arm (Rocker-Arm)
- Torsion Bar (5) Is Splined on Each End for Insertion into Collet (Inner Sleeve) (15)
- Inner Sleeve (Collet) Is Splined and Firmly Attached to Sidecar Frame Tubing
- Axle of Rocker-Arm (3) Is Hollow with Internal Splines to Accept Torsion Bar
- Sidecar Wheel Moves Up-and-Down Relative to the Frame, Twisting Torsion Bar
- Vibrations Are Absorbed by Elasticity of Torsion Bar
- Movement of Lever Is Limited in the Vertical Plane by Bracket (9) Welded to the Right Longitudinal Tube of the Sidecar Frame
- Maximum Upward Blows on the Lever Arm Are Absorbed by Rubber Buffer (10), Attached to Limiter-Stop Bracket (9)
K-750, M-61 and M-62 Sidecar-Wheel Torsion Bar (cont.)

1. Torsion Cap
2. Seal Clip
3. Axle of Lever Hub
4. Rear Tubing of Sidecar Frame
5. Torsion Bar (Rod)
6. Locking Screws
7. Claw-Shell Clamp to Motorcycle Frame
8. Left Tube of Sidecar Frame
9. Travel Stop Arm
10. Rubber Buffer
11. Sidecar Wheel Axle
12. Axle Lever (Rocker-Arm)
13. Seal
14. Ring Seal
15. Collet (Splined Inner Sleeve)
The rear-wheel is suspended on a trailing swing-arm, pivoting on rubber (silent-block) bushings located by removable pins in the frame and supported by dual hydraulic shocks/springs. The final drive attaches to the right-hand side of the swing-arm. The sidecar-wheel is carried on a forked, trailing-link swing-arm, supported by a single hydraulic/shock/spring, pivoting in silent block bushings around long bolts (“lever pins”).
• Sidecar Frame (Chassis)
  – Welded Tubular Frame
• M-61 / K-750 Sidecar Frame Fastened to Motorcycle Frame at Four Points
  – Two Ball Chucks (collets) at Bottom (to motorcycle frame)
  – Two Bolted Connections at Top (front under tank and rear behind the saddle)
  – Ball Joints on Motorcycle and Collets on Arms of Sidecar Frame
  – Petal-Shaped Bowl Draws Ball into Socket Using Bolt
  – Tie-Rods Adjustable in Length, Allow Alignment Relative to Motorcycle
• Sidecar Wheel Axle Resiliently Isolated from Frame by Torsion Bar / Rocker-Arm
  – Swing-Arm Lever Pivots on Sleeve Bearing with Rubber-Metal Bushings (Silent-Blocks)
  – Torsion Bar, Spring Shock Absorbers (like shock absorbers installed in rear-wheel suspension), and Rubber Mounts Used for Isolation
  – Torsion Bar Implementation
    • Sidecar Wheel Axle (1) Mounted on Rocker-Arm (2)
    • Torsion Bar (3) Twists as Rocker-Arm Moves Up-and-Down
• Ural M-61 Sidecar Dual Leaf-Springs
• Dnepr’s K-750 Sidecar Has Rubber Isolators Instead of Leaf-Springs
The rocker arm for the sidecar axle was isolated using a torsion bar mounted in the rear cross-member of the sidecar tubular frame. Ural’s M-61 sidecar still retained the dual leaf-springs for suspension, whereas Dnepr’s K-750 used rubber bumpers plus the torsion bar.
Ural M-63 Frame and Sidecar (Рама и коляска)

- Frame Is Main Weight-Bearing Element
  - All Components and Assemblies Are Attached
  - Double, Tubular, Welded, Closed Type of Frame

1 - motorcycle frame
2 - front motor pin
3 - front collet chuck
4 - bolt collet
5 - motorcycle stand
6 - foot brake pedal
7 - step right driver
8 - supports clipboard
9 – sidecar rod mounting frame
10 - passenger footrest
11 - sidecar frame
12 - spring
13 - spring clamp
14 - wheel axle lever
15 - sidecar wheel axle
16 - protective cap kit
17 - protective disc brake drum
18 – buffer
19 – sidecar fender
20 - turn lamp
21 - carrier body attachment
22 - shoe springs
23 - back collet chuck
24 - idler arm rear suspension
25 - shock absorber
26 - license plate bracket
27 - yoke back plate
28 - passenger seat
29 - passenger handle
30 - back plate
31 - driver’s seat
32 - gas tank bracket
33 - left footrest Driver
34 - bracket motor
35 - rear motor hairpin
36 - adjusting fork rod
37 - sidecar rod mounting frame

Sidecar frame is connected to the motorcycle frame thru collets 3 and 23 and two rods (9 and 37). At the rear of the frame are welded brackets for the quarter-elliptic leaf springs. The sidecar wheel frame (11) is connected to the torsion bar suspension. To protect against contamination of brake drums, the inner cavity is closed (17).
The torsion arm is mounted in the rear transverse frame tube (4). The torsion bar (5) has ends of small triangular splines for connecting the inner tube and the axis of the coupling arm (15). The inner sleeve has a slot-pipe hole and is welded to the frame tube. The axis arm (3) is hollow with internal splines. Outer surfaces polished lever pivot pin mounted in the hub axis (3). At the outer end of the shaft lever attached a woodruff key and bolted wheel axle lever (12). The hub axis of the arm is inserted into the back of the frame cross (transverse) tube and the flange is attached to the frame of the sidecar. Moving the lever wheel axis in the vertical plane is limited by the bracket (9) welded to the right of the longitudinal frame tube. Sharp fluctuations are absorbed by the rubber buffer (10) attached to the bracket.
Mounting Rods or Sway Bars and Claw Fittings

Sidecar Attachment Clamp Joint
1. Clamp (Collet or Claw)
2. Nut
3. Bolt

Sidecar Mounting Bar

Sidecar Attachment to Motorcycle
1. Front Tie Rod
2. Middle Tie Rod
3. Rear Clamp
4. Front Clamp

Collet or “Clamshell”

Sidecar Claw Coupling
With the tub removed, the sidecar drive shaft and gear reducer is clearly seen.
Because Ural’s M-63 / M-66 / M-67 do not offer 2WD, the swing-arm is not C-shaped on the open end.
The M-63 was the first Ural to use a rear-wheel, swing-arm suspension. Unlike Dnepr (KMZ) bikes, the swing-arm is on the outside of the frame.
As strange as it may seem, Ural changed motorcycle and sidecar suspension in mid-stream. I’m sure that never happened before!
Pining Down the Year of Change

It appears that by 1968/70, Ural had instituted changing replacing the plunger with the swing-arm on the motorcycle and replacing the torsion bar with a swing-arm on the sidecar.
1WD versus 2WD Suspension of Rear Drive

- Swing-Arms Differ on the Drive Side
  - 1WD Swing-Arm Has a Simple Plate Which Bolts to Four Studs around the Axle Hole of the Rear Drive Casing
  - 2WD Swing-Arm Has a C-Shaped Fork Which Attaches to the Circumference Bolts on the Rear Drive Casing
MT-16 Rear Drive and Sidecar Wheel Gear Reducer

(Ken Ulrich U-2 Cycles)

Swing-Arm Suspension

Differential rear Drive, Transverse Axle and Sidecar Gear Reducer

Sidecar Pendulum Gear Reducer and Sidecar Wheel Brake

Sidecar Pendulum Gear Reducer

2WD Swing-Arm Suspension
The sidecar frame is coupled to the motorcycle frame through collet clamps (10), rear collet clamp brackets (17) and two frame legs (9, 13).
Examining the Chang Jiang (CJ750) Motorcycle

• Chang Jiang (CJ750) Is Daughter of M-72
  – CJ750 Motorcycle and Sidecar Based on the 1956 Soviet IMZ (Irbitski Mototsikletniy Zavod) M-72, Which Was Derived from the 1938 German R71
  – In the USSR, Now That the Side-Valve (SV) Model Had Become Obsolete, Manufacture of the Old M72 Offered It to Their Chinese Neighbors
  – In 1957, the M-72 IMZ Production Line Transferred to People’s Republic of China (PRC) State-Owned, Gan Jiang Machinery Factory, and Renamed the Chang Jiang 750
  – Early Motorcycles Built Using Various Imported Russian Parts, and Even Some Complete Russian-Made M-72s Relabeled as CJ750
  – Side-Valve CJ750 Still In Production with Few Changes from Original Design

• Examining the Chang Jiang (CJ750) Helps to Understand the Modern M-72
  – Often the CJ750 Drawings Are Copies of 1955 M-72 Drawings

• Chang Jiang 750 M1, CJ750 M1S (Super) and CJ750 M1M All Have Torsion Bar Suspension, Rocker Arm for the Sidecar Suspension and Plunger Rear Wheel Suspension
Chang Jiang (CJ750) Side-Wheel Axle Assembly
(Sidecar-Wheel Shaft Rocker Arm)

1. Split Pin (Cotter Pin)
2. Castle Nut
3. Washer
4. Drum Cap
5. Rocker Arm
6. Torsion Rod
7. Side-Wheel Shaft
8. Screw
9. Washer
10. Rubber Buffer
11. Bolt
12. Plug
13. Locking Spring Ring
14. Nut
15. Tab Washer
16. Lip
17. Sealing Gasket
18. Felt Ring
19. Sealing Washer
20. Bushing
21. Fly Sleeve
22. Fly
23. Key
24. Bolt
25. Washer
26. Washer
27. Split Pin (Cotter Pin)

The CJ750 diagram clearly shows the torsion bar in the 1951 version of the Russian M-72.
The CJ750 sidecar frame assembly mimics the 1951 version of the Russian M-72.
Because it was a Chinese, we can see some of the old features of the M-72, including the sidecar.
The CJ750 sidecar frame assembly clearly shows the attachment points for the plunger suspension system.
Modeling of the old M-72 sidecar clearly shows the rigid frame over the fender.