Title: Rectification of 20/90 Dragline

By

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Dragline: Walking dragline 20/90 manufactured in collaboration with Russia is a powerful excavating machine used for removal of overburden in open cast mining of coal, lignite and minerals in large construction sites of irrigation projects. It is an excavating machine in which the bucket is attached by cables and operates by being drawn toward the machine. The machine consists of:

1.Body, 2. Boom Winch, 3.Hoist Rope Pulley, 4. Jib Crane, 5. Boom Suspension, 6. Supporting System, 7. Boom head pulley, 8.Hoist Ropes, 9.Bucket, 10.Drag Ropes, 11.Boom, 12.Drag Ropes Pulley, 13.Leading Pulley, 14.Shoes, 15.Auxiliary Cylinder, 16.Tub, 17.Main Cylinder, 18.Revolving frame.

Parameters of 20/90 Dragline:

1. Bucket Capacity: 20 m^3
2. Boom Length: 90 m
3. Boom Angle: 32^0
4. Maximum Suspended Load: 63 t
5. Maximum Dumping Radius (Operating): 83 m
6. Maximum Dumping Height: 38.5 m
7. Maximum Digging Depth (Straight): 42.5 m
8. Average Specific Ground Pressure when operating: 0.115Mpa
9. Maximum Angle in travel: (a) Longitudinal: $\pm 7^0$, (b) Cross: 3^0
10. Travel Speed on Horizontal average: 0.022 m/s.
11. A C Supply voltage at 50 Hz: 6600 Volts.
12. Synchronous Motor Rating: 2500 KV.
13. Dragline weight except balancer box, spare and fixtures: 1700 t.
14. Balance box weight by client: 40 t.
15. Tail part Clearance Radius: 19.7 m.
16. Clearance under revolving frame: 1.61 m.
17. Rope Diameter: 54 mm.
18. 120^0 single Cycle: 60 s.
19. Total Weight: 1810 t.

Vibration and noise level in operator's cabin is within sanitary standards and regulations.

BOOM: It is a rectangular lattice construction comprising of tubular member of high tensile strength along with 32 numbers of gay ropes with length of 90 m at 32^0 inclinations.

It holds the bucket with hoist and drag ropes at Boom head side and allows the machine to a reach of 83 m for digging the overburden.

PROBLEM: A 560 mm long crack was detected at the lower side of the lower chord (left) of the Boom (Refer Sketch-III) of the 20/90 Dragline. It was at a height of 8 m above the ground. The Boom is made out of pipe diameter 820 X 8.5 mm. The Boom structure is supported by 32 gay ropes. The author along with a welder rushed to the site to examine the problem and to carry out necessary corrective measures.

Crack is defined as a discontinuity caused by the tearing of the metal while in a plastic condition (Hot Crack) or by fracturing of the metal when cold (Cold crack). It represents a failure under stress of a metal when it is behaving in brittle manner, i.e. it is inclined to fracture without deformation.

Chemical and Mechanical properties of the pipe material of the Boom of the 20/90 Dragline:

Material of the Pipe: 17ГС (GOST)

Chemical Composition:

C	Si	Mn	Ni	S	P	Cr	N	Cu	As
0.14 - 0.2	0.4 - 0.6	1 - 1.4	max 0.3	max 0.04	max 0.035	max 0.3	max 0.008	max 0.3	max 0.08

Mechanical Properties:

Tensile strength	Yield strength	Elongation	CVN Impact value at -40°C
MPa	**MPa**	**%**	**Joules**
510	**343**	**23**	**44**

SOLUTION: For reaching the height at which the crack was developed a special platform was fabricated and assembled at the top of a Tanker.

The following steps are followed:

1. **Two numbers of crack arresting holes have been drilled at both ends of the crack to avoid further propagation of the crack.**

2. **The Crack was removed by grinding. It was cleaned thoroughly by brushing and grinding**.

3. **D P Test was conducted to ensure non existence of any surface defects.**

4. **Pre heating was done up to 200^0 C.**

Pre heating before welding and stress relieving after welding is good insurance against cracking. Pre heating before welding reduces shrinkage stresses, thermal stresses and localized hardness. Carbon steels with a minimum tensile strength from 70, 000 Psi are normally subjected to Pre heating before welding.

Formula for calculating the preheat temperature

$$CE = \%C + \frac{\%Mn}{6} + \left(\frac{\%Cr + \%Mo + \%V}{5}\right) + \left(\frac{\%Cu + \%Ni}{15}\right)$$

=0.2+1.4/6+ (0.3+0+0)/5+ (0.3+0.3)/15=0.53

CE is the carbon equivalent considering chemical composition.

CT= CE X 0.005 X t=0.53 X 0.005 x 8.5= 0.02

CT is the carbon equivalent considering the thickness (t) of the material in mm.

Total Carbon Equivalent (TCE) = CE + CT = 0.53+0.02 = 0.55

Preheat temperature ^{0}C = 350 √ (TCE-0.25) =350 √ (0.55-0.25) = 192 ^{0}C.

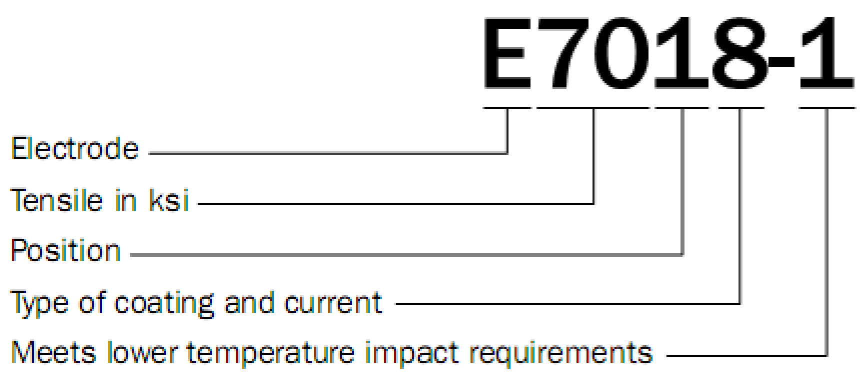
5. **Welding has been carried out using SMAW (Shielded Metal Arc Welding) process with pre dried electrode E 7018-1, AWS SFA 5.1, Ø 3.15 mm.**

   Shielded metal arc welding (SMAW), also known as manual metal arc welding (MMA or MMAW), flux shielded arc welding or informally as stick welding, is a manual arc welding process that uses a consumable electrode covered with a flux to lay the weld.

   An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. The work piece and the electrode melt forming the weld pool that cools to form a *joint. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve*

as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination.

Because of the versatility of the process and the simplicity of its equipment and operation, shielded metal arc welding is one of the world's first and most popular welding processes. It dominates other welding processes in the maintenance and repair industry, and though flux-cored arc welding is growing in popularity, SMAW continues to be used extensively in the construction of heavy steel structures and in industrial fabrication. The process is used primarily to weld iron and steels (including stainless steel) but aluminium, nickel and copper alloys can also be welded with this method.



Chemical Composition:

Si	Mn	Ni	V	Cr	Mo	Mn+Ni+Cr+Mo+V
Max 0.75	max 1.6	max 0.3	max 0.08	max 0.2	max 0.3	max 1.75

Mechanical Properties:

Tensile strength	Yield strength	Elongation	CVN Impact value at -46°C
MPa	**MPa**	**%**	**Joules**
500	**410**	**22**	**27**

6. U T has been conducted and the welding was found o.k.

7. **Stress relieving has been done as per sketch-I.**

Stress relieving reduces thermal stresses, removes localized hard zones, promotes relaxation by reducing the yield strength of the metal below the imposed strength and reduces general hardness in the joint.

Control heating and cooling rates: Thermal stresses are caused by the expansion of the material in a localized area. Approaching the stress relieving temperature can introduce thermal stress in the metal just as arc temperature does. The difference is that thermal stresses will be located farther from the joint. A slow controlled heating rate provides a low temperature gradient by allowing heat run out in the metal, and prevents thermal stress. Stress relieving temperature generally is 100 ^{0}F below the critical range of the metal, the temperature interval within which austenite forms in ferrous alloys.

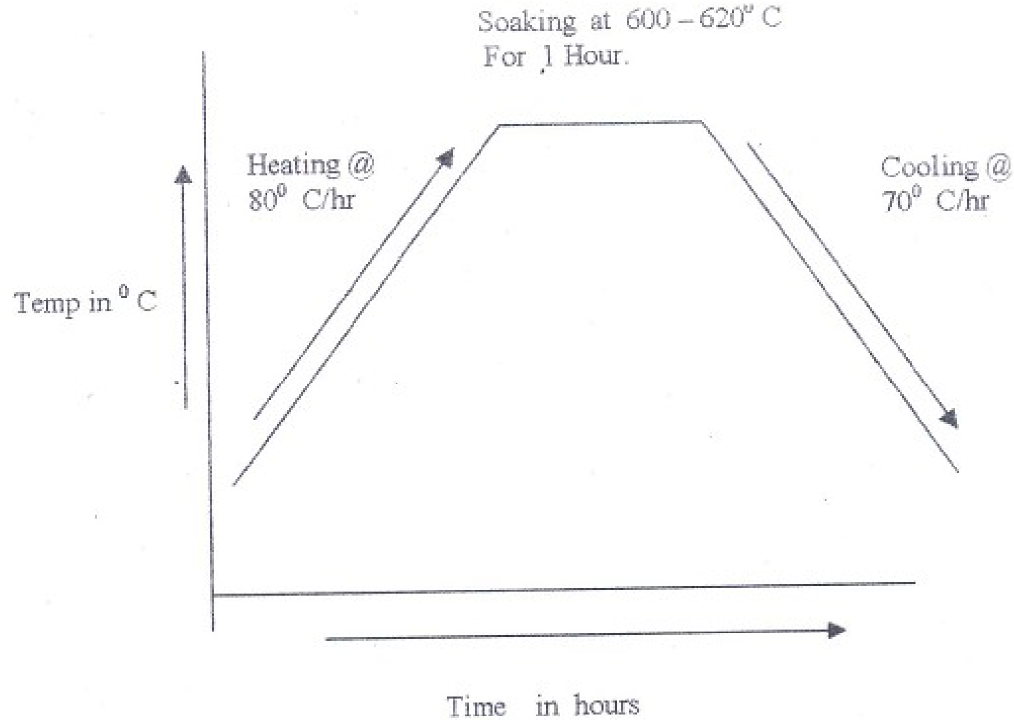
The soak time depends on the thickness of the metal, by rule of thumb, 1hr per inch of the thickness. The soak time ensures an even distribution of heat throughout the thickness, permits a long heat run out to help eliminate thermal stresses and insures complete relaxation of metal to relieve residual stresses. The controlled cooling rate reduces quenching action which can cause hard spots in the metal and also greatly contributes to low even hardness. Uniform cooling rate prevents new stresses from being set up in the joint.

8. **A Jacket has been assembled with the help of a screw jack.** The jacket was cut from a pipe of a damaged Boom as per sketch-II. The jacket was gas cut in a special shape (refer sketch-II) so as to avoid welding in a straight line which would cause concentration of stresses. The corners were also rounded to R50 to avoid stress concentration points. With proper preheating the jacket has been welded to the boom as per sketch-III. Post heating has been done at 300^0 C for two hours.

Post Heating: It is a customary to post heat the weld after welding which require preheating. The main purpose of post heating is to lower the cooling rate of weld ment and heat affected zone. This would lead to

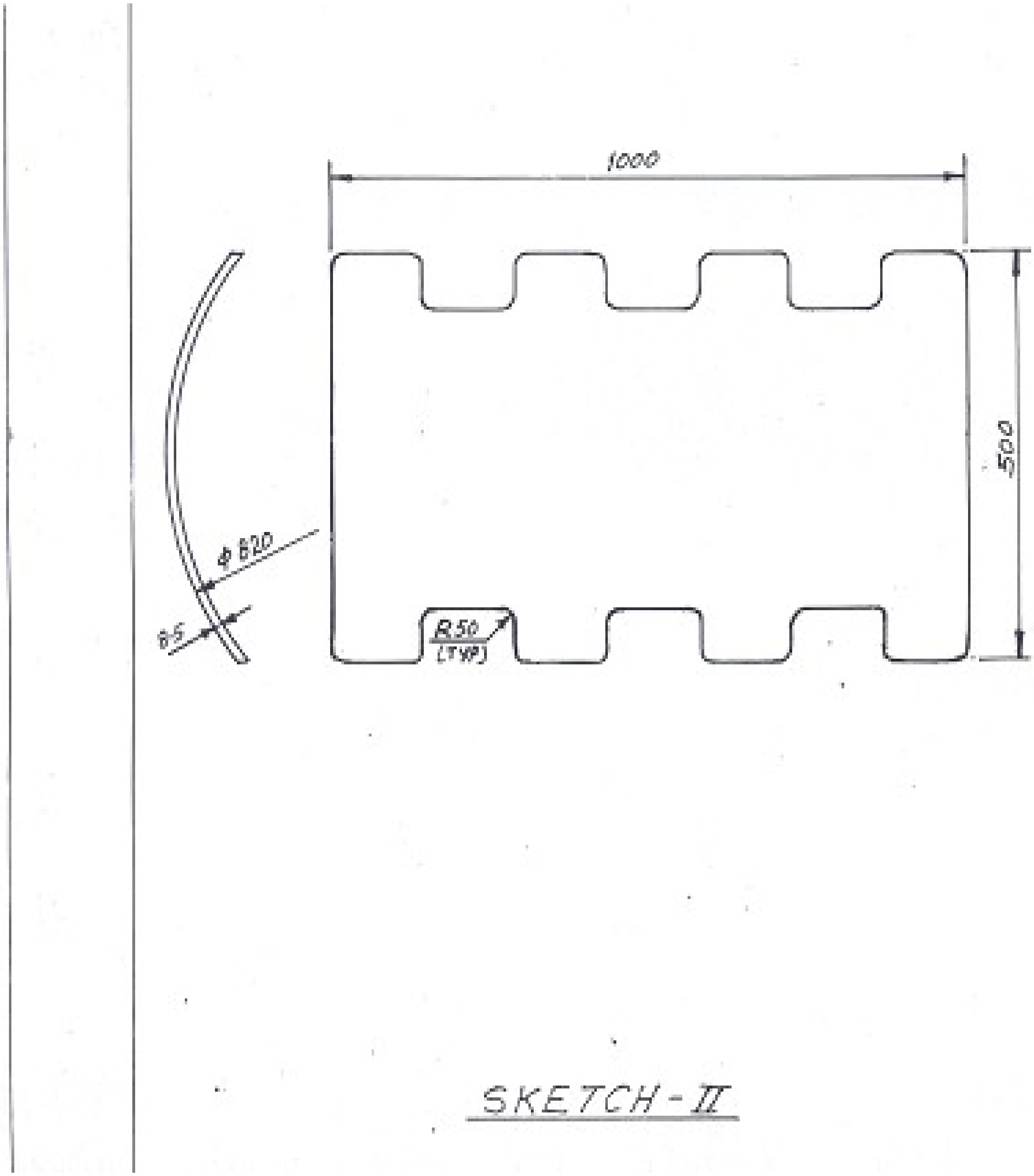
(a) Slow cooling of weldment which helps in liberation of hydrogen.
(b) Lower the hardness of the weldment.

STRESS RELIEVING CURVE

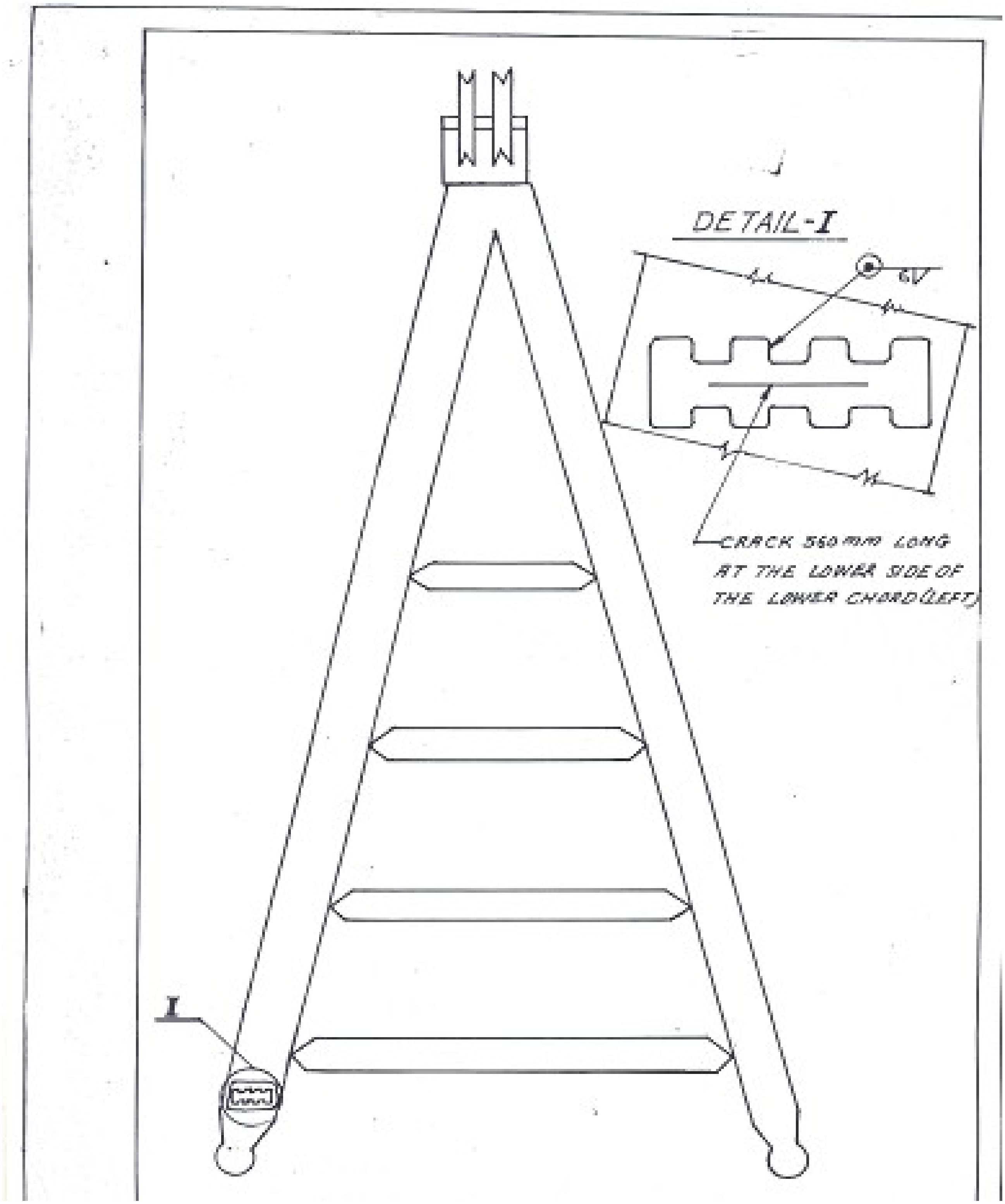


Sketch - I

JACKET

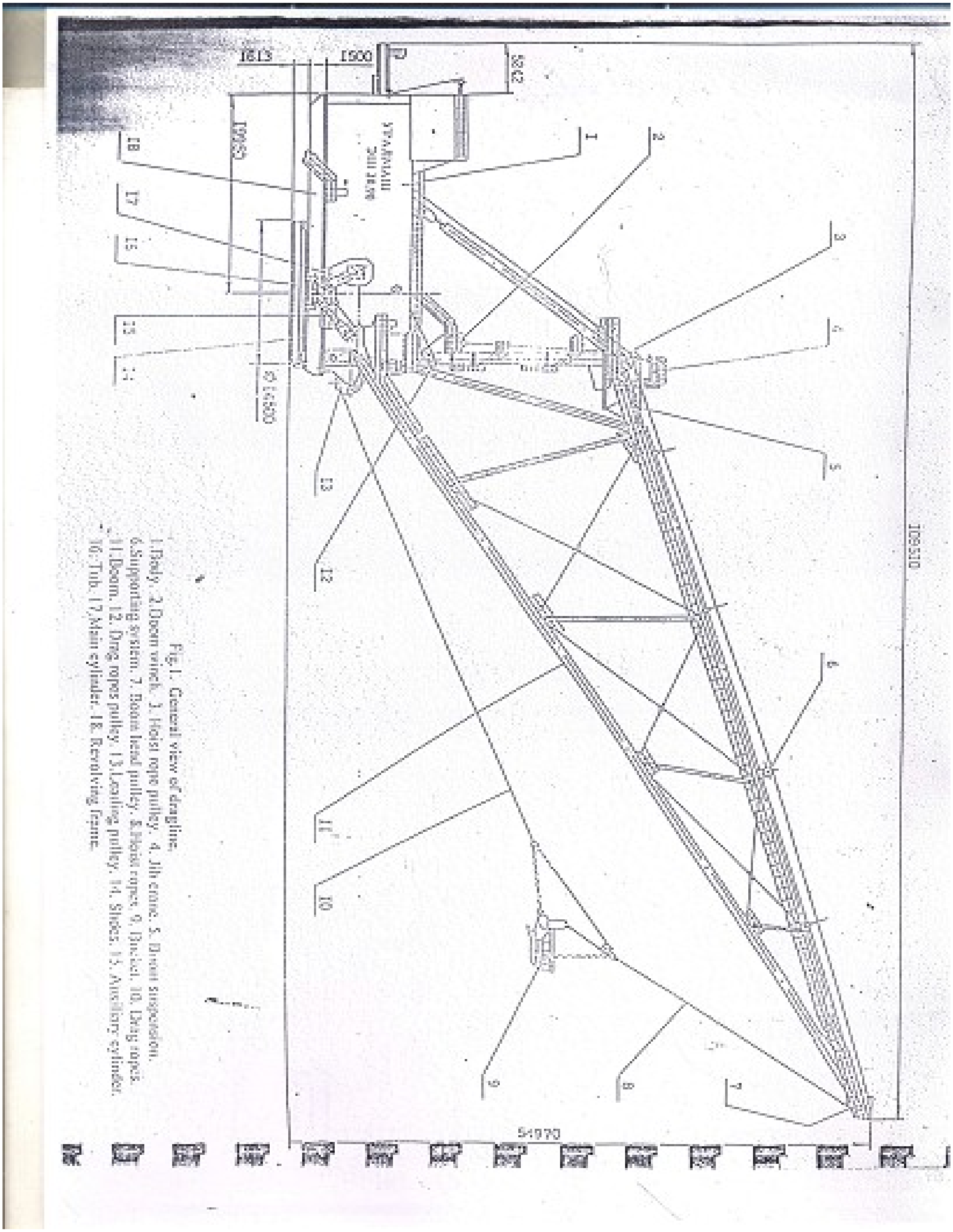


LOWER CHORD OF BOOM



SKETCH-III

GENERAL VIEW OF DRAGLINE



20/90 DRAGLINE

The rectification/repair of the dragline has been completed successfully and the machine is working satisfactorily.

Thank you

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