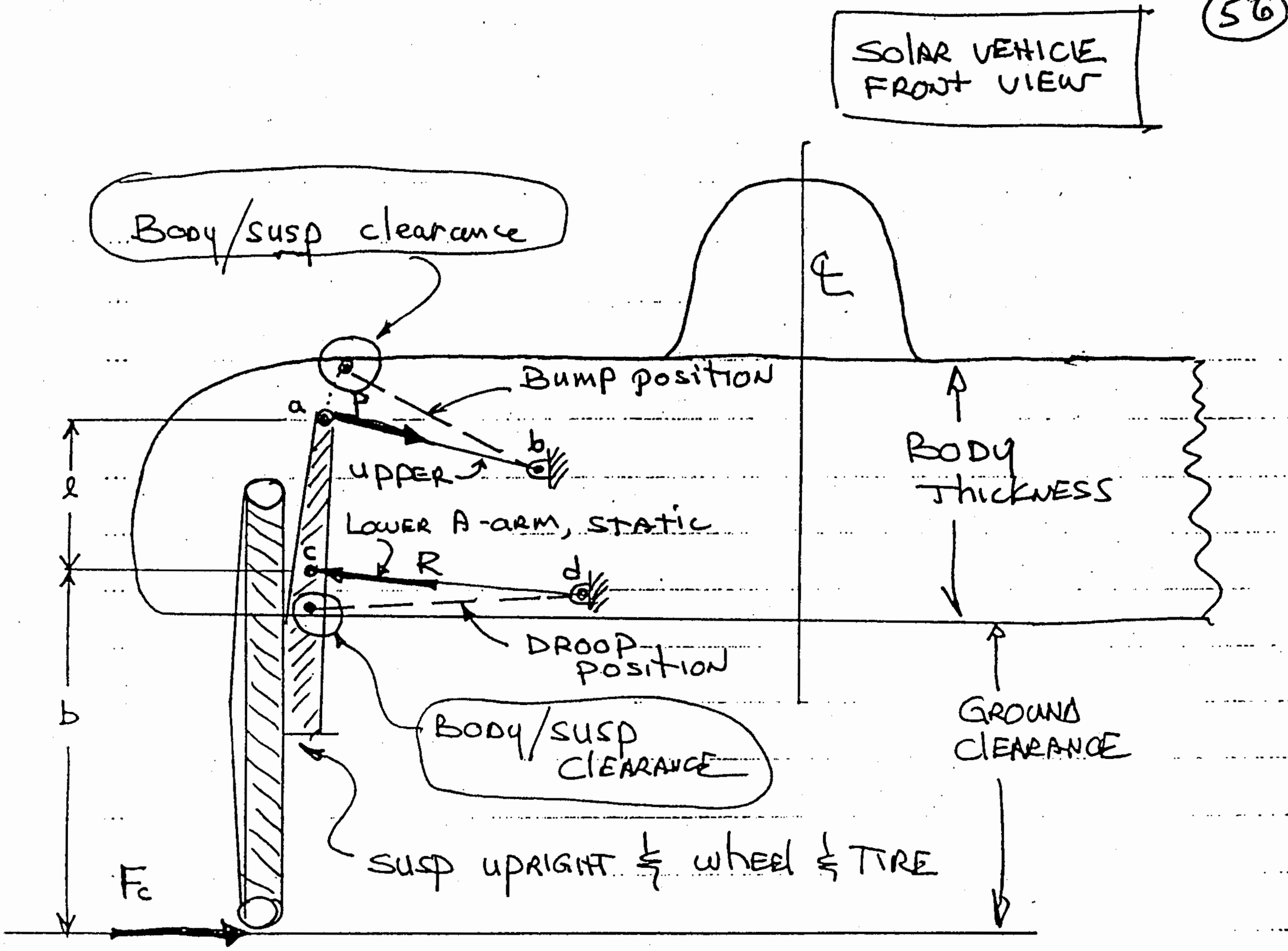
Handout 4 Solarcar Suspension Issues

This handout describes some issues regarding the forces, geometry and construction of a double A-arm suspension for a solarcar with 3 wheels, (two in front that have the suspension and do steering)

There are nominal values that must be selected before the suspension choices, such as:

- Front track — TR.
- Ground Clearance at "axle."
- Diam of Tires (loaded) ~ see handout 15.
- Kingpin inclination angle <10°.
- Offset (Also called "scrub radius") — use ½" to 1".
- Distance from vehicle ℄ to the "vertical panel" at axle line.
- "Droop" ~ suspension movement downward from static position, at the wheel.
- "Bump" ~ susp. movement upward … (as above).
- Body clearance (closeness) above the tire or suspension at Bump.
- fairing/Body treatment for clearance at droop.
- Steering angles of the front wheels.

The follow page shows some interactions that were described in the Solar Vehicle Seminar —



Mechanical / Aero Interactions

Aero: small Body Thickness,
HIGH GROUND CLEARANCE
A-ARMS out of AIRSTREAM

Mech: 2-3 inches of Bump TRAVEL } "JUDGEMENT"
$1\frac{1}{2}$ - $2\frac{1}{2}$ inches of DROOP TRAVEL }
DIMENSION l "Large" ⇒ Thick Body
DIMENSION b "small" ⇒ Low Ground Clearance

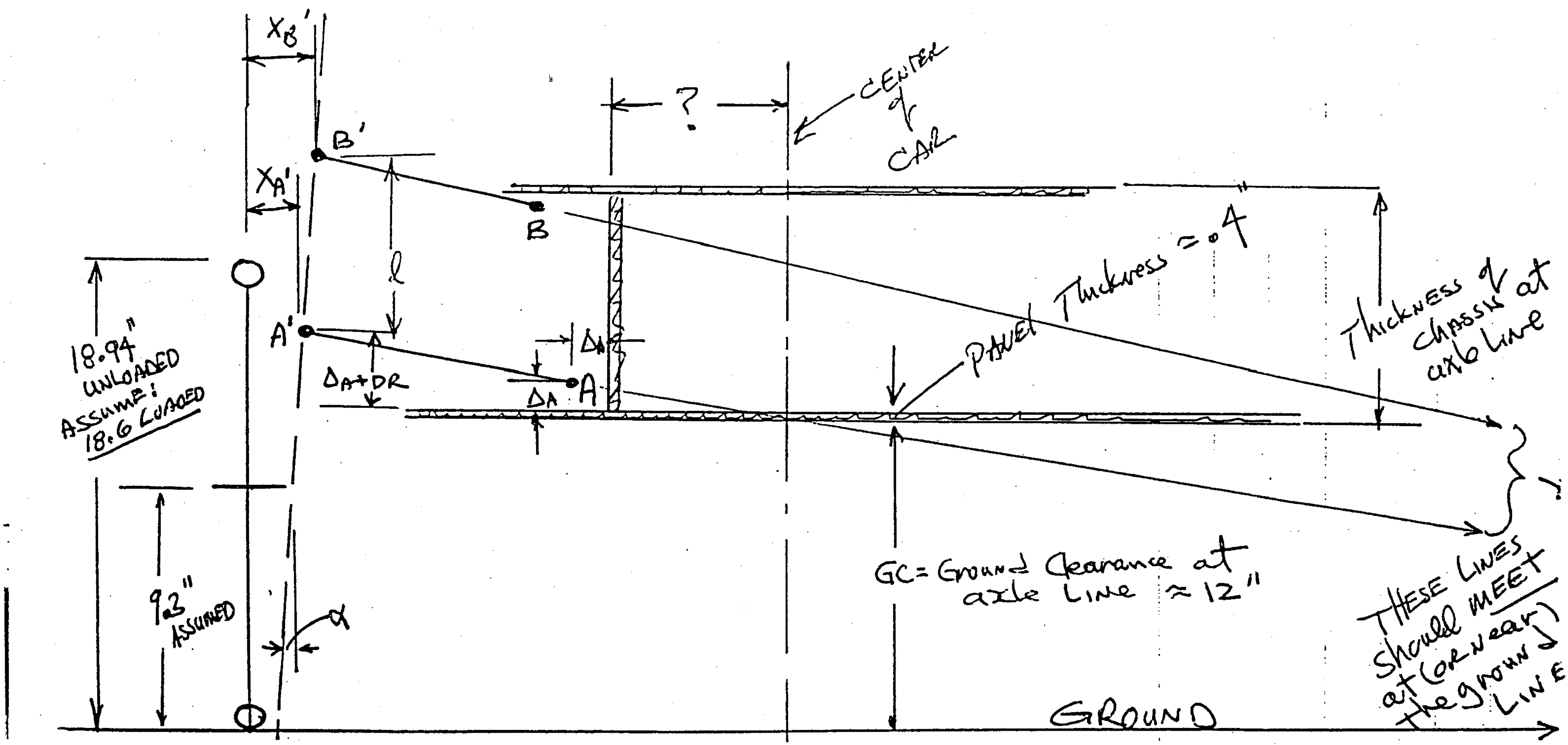
Since Reactions $P \approx \left(\frac{b}{l}\right) F_c$ ← CORNERING FORCE F_c

$R \approx \left(\frac{b+l}{l}\right) F_c$

The NEXT PAGE shows a general layout for a solarcar using composite panels as the chassis. The design choices are to locate pivots A, A', B, B'. The figure shows Kingpin inclination α and offset denoted as "OFF".

Roll center / Swing Arm Length

The FRONT Roll center for a 3 wheeled vehicle that has an aerodynamic shape and travels at 65 mph+ should be on the ground. The single REAR "Rolls" about its contact patch which is on the ground, so the roll axis will be a horizontal line on the ground down the vehicle centerline. This will give no change in the angle of attack of the aerodynamic body when leaning. There are many ways to achieve a ground level roll center – We will use one that assists in minimizing Bump Steer. We will Require that the lines through B-B' and A-A' will meet at the ground. This will put the Roll center on the ground and produce a "long" swing arm length.



X_B'
X_A'
B'
B
A'
A
?
CENTER of CAR
ℓ
Δ_A
$\Delta_A + D_R$
PANEL Thickness = .4"
Thickness of chassis at axle line
18.94" UNLOADED
ASSUME: 18.6 LOADED
9.3" ASSUMED
α
GC = Ground Clearance at axle Line ≈ 12"
THESE LINES should MEET at (OR Near) the ground LINE
GROUND

ISSUES REGARDING EACH A-ARM pivot will be EXAMINED.

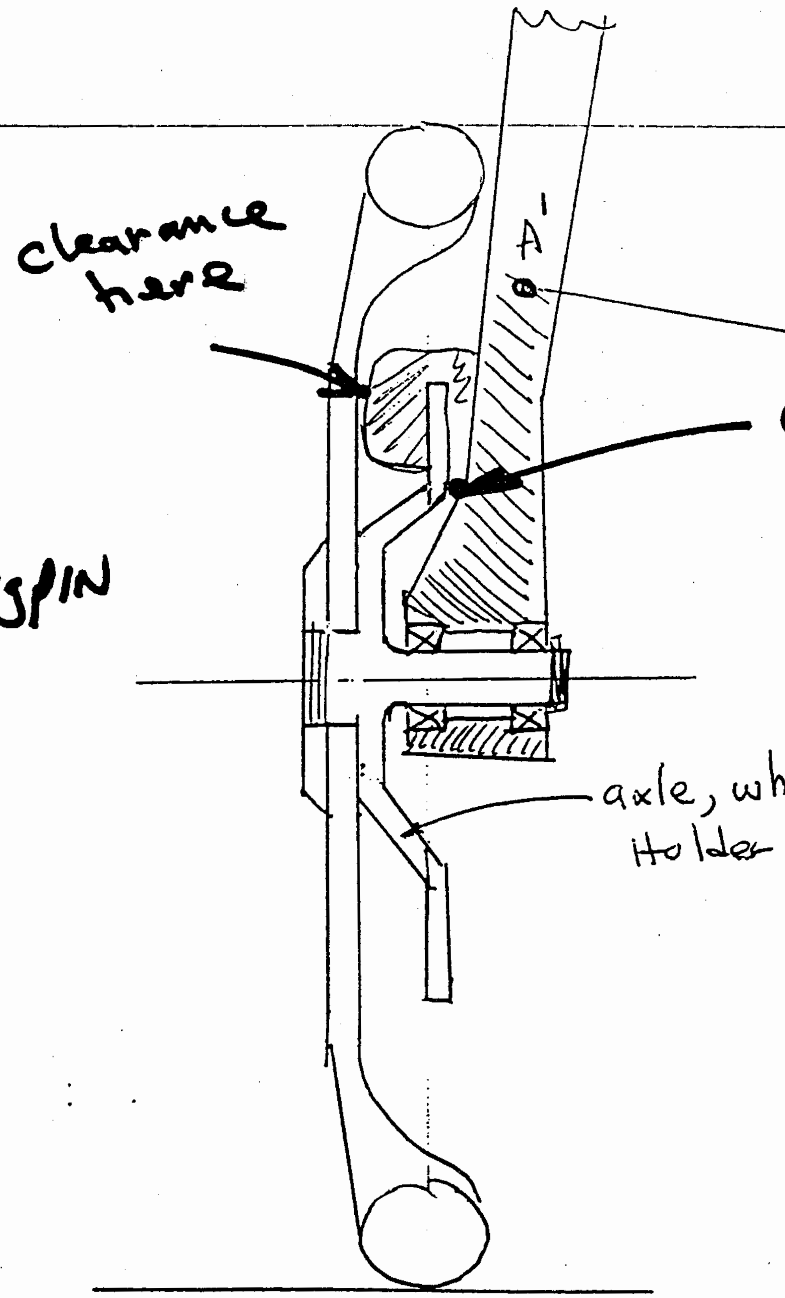
Pivot A ~ WANT A "Longer" A-arm to REDUCE ARM ANGLE CHANGES SO we have more mounting clearance options,
~ want point A to be as low as possible to reduce forces,
~ ΔA is the offset of the actual pivot from the floor and vertical panels - due to the machinery of the pivot and bracketry - we want ΔA to be small.

Pivot A' - This is where the Lower A-ARM and the upright meet - The lower ARM goes up and down from static position and the upright turns on the kingpin axis when steering. The main thing is to get a reasonable value for X_A' → The horizontal distance from the tire centerline (℄) and the vertical line through A'. Small values of X_A' can produce small loads in Bump (in the A-arms), but much machinery has to fit between A' and the tire centerline. We started with $X_A' = 1.6''$ for Borealis and ended up with $X_A' = 2.0''$. The next two pages show some sketches that were made before we knew about NGM wheels - we were considering making our own wheels for Aurora 3.

option II

axle ROTATES

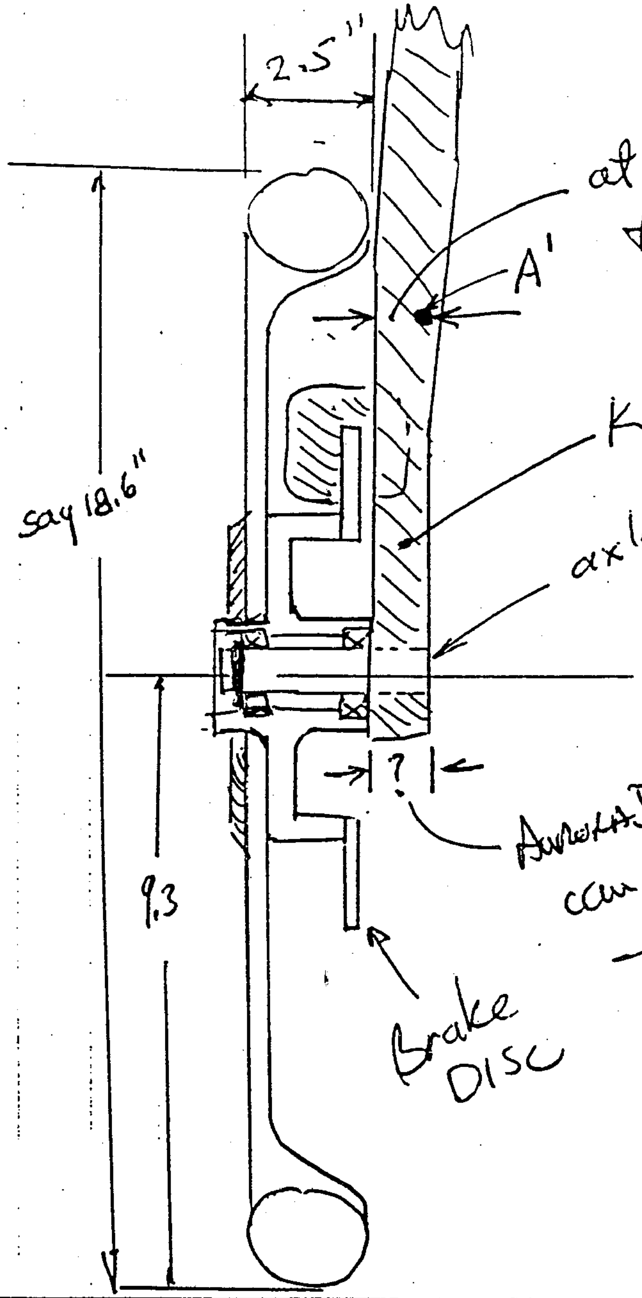
Bis IN the KingPIN



- CONCERNS
- Bearing placement
- overall width Below A'
- weight
- ease of MFG.

option I

axle stays still, hub Rotates



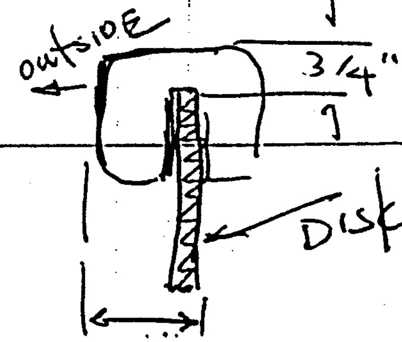
at least 1" from outside edge to pivot } Looks Like $X_A' \approx 2\frac{1}{4}$"

KINGPIN

axle pressed ? IN — need to examine methods

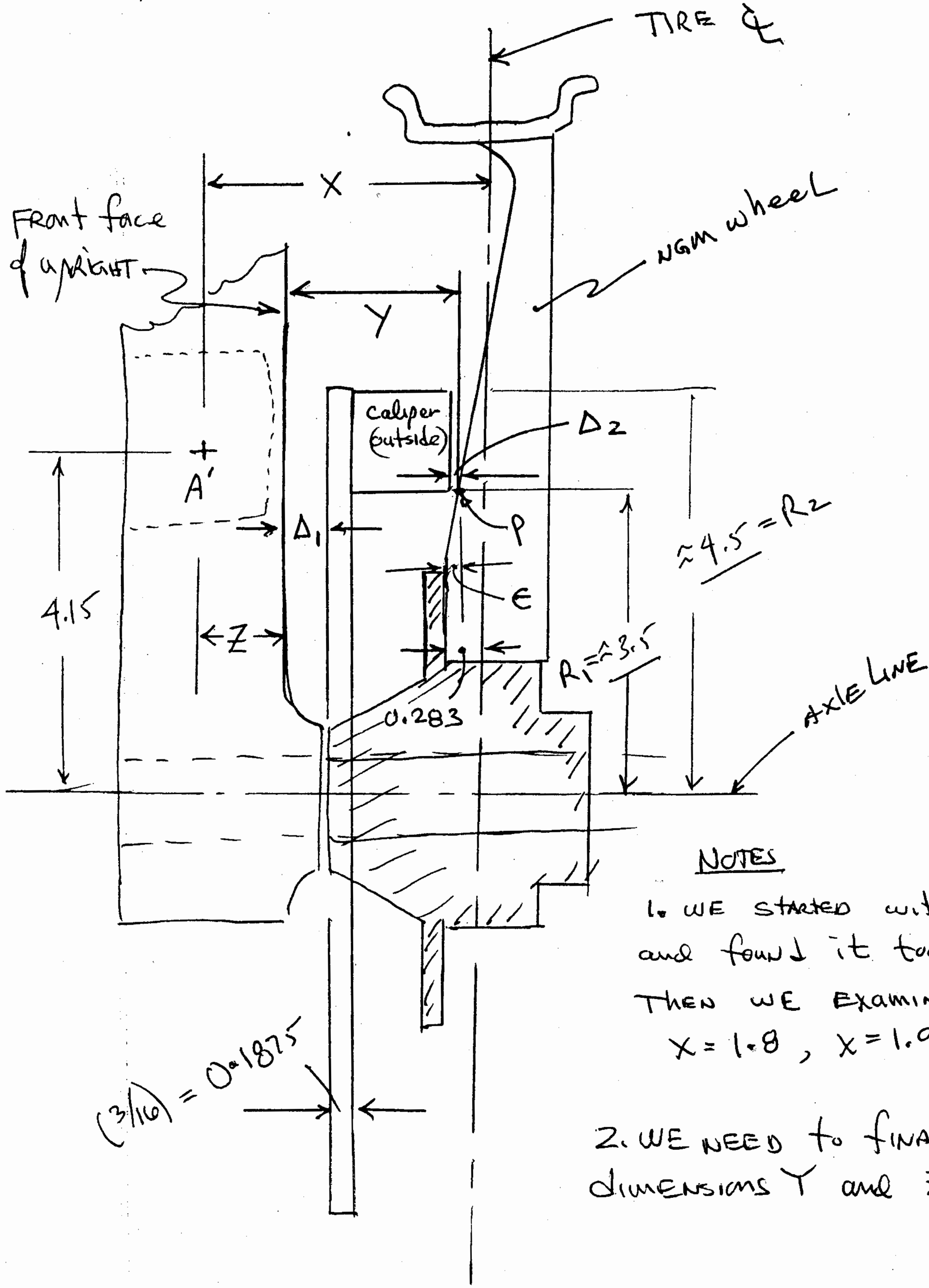
AuroraII had 1.8" ? can we do with 1" ?

- Brake Disk DIAM ?
  use 8" OD
  6" ID
- Caliper ?



The next 3 pages show some Borealis notes and sketches, ending up with a dimensioned drawing of the various clearances with $X_{A'} = 1.90$ inches. We eventually had $X_{A'} = 2.00$ inches.

Point B' - This has to work with A' to achieve the desired ranges of angle α and the offset value. It is also good if distance l can be "big". Borealis had $l \approx 5.6$ inches which is probably on the small side. Examine the formulas for the reactions at A' and B' in Handout 4 to see the role of the various dimensions and their ratios. Increasing l will raise B' so it may get too close to the body. Point B' is also where we may want to make camber adjustments, so the machinery of the pivot must be considered. Examine the drawings of Aurora 4's upright in Handout 12, which shows a double-shear joint and camber adjustments with spacers. For Borealis, we used a single shear pivot, with a 3/8 bolt to lower the whole assembly.



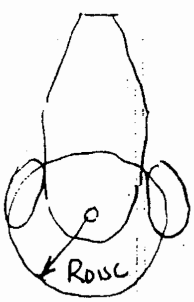
NOTES

1. WE STARTED with X=1.6 and found it too small THEN WE EXAMINED X = 1.8 , X = 1.9 ?

2. WE NEED to finalize dimensions Y and Z

3. we need to accurately identify the caliper width with "new pads"

4. we need to identify the location of the ~~[illegible]~~ smaller radius of the caliper when mounted ~ R_1
THE AURORA[4] BRAKE discs were 9" IN DIAM — assume we keep these — or see what difference 8" DIAM would make (the calipers may not fit because of the width of the upright) —



4a. and the location of point P on the wheel with respect to the ℄ OR inner mounting face } ε

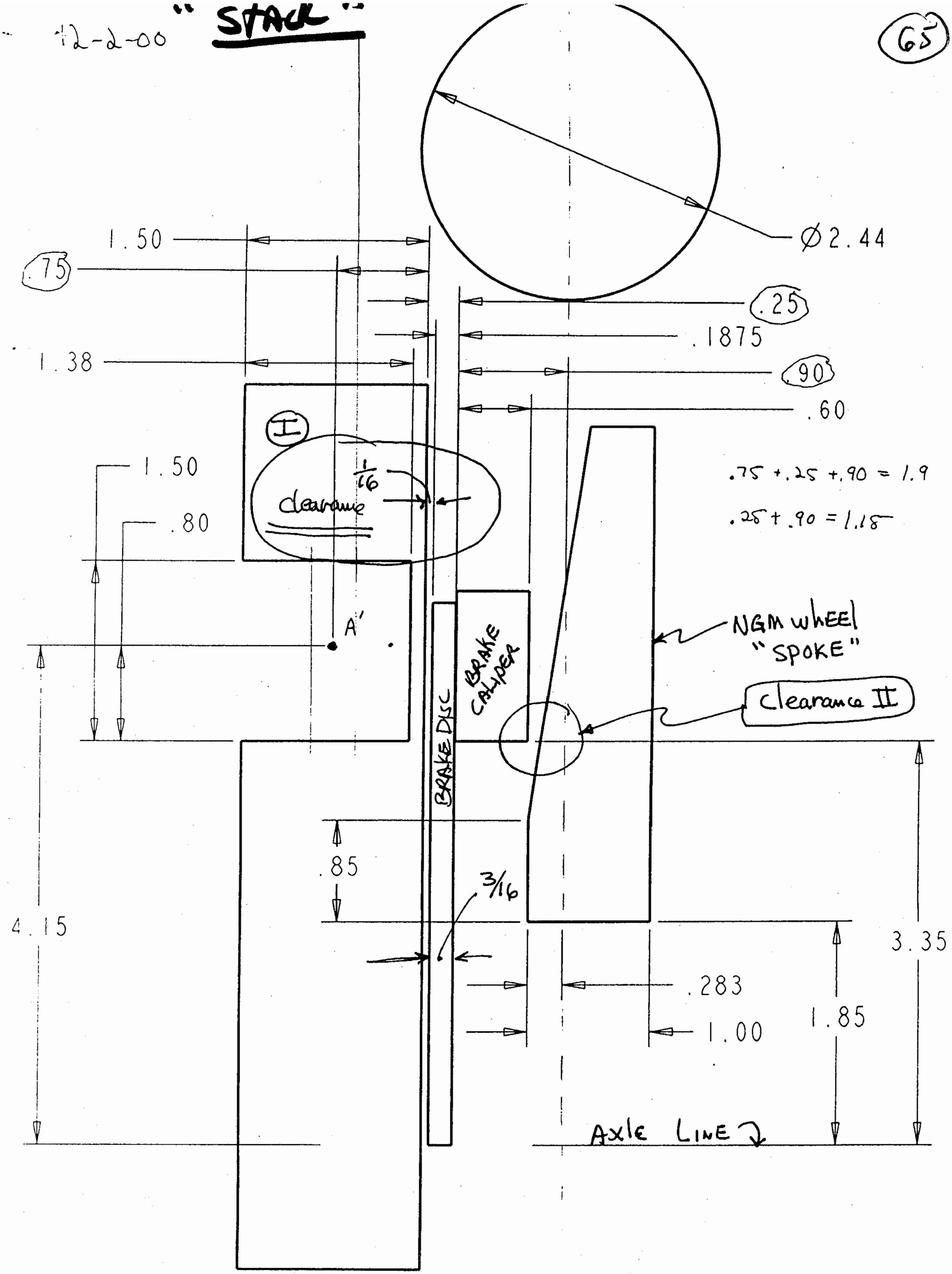
5. then the stack of dimensions and clearances that make up Y can be examined —

caliper width + disc width + $\Delta_1 + \Delta_2$ = Y

6. The wheel inner mounting face is 0.283 in-ward from the wheel ℄ —
(taken from the wheel drawing by NGM and not checked)

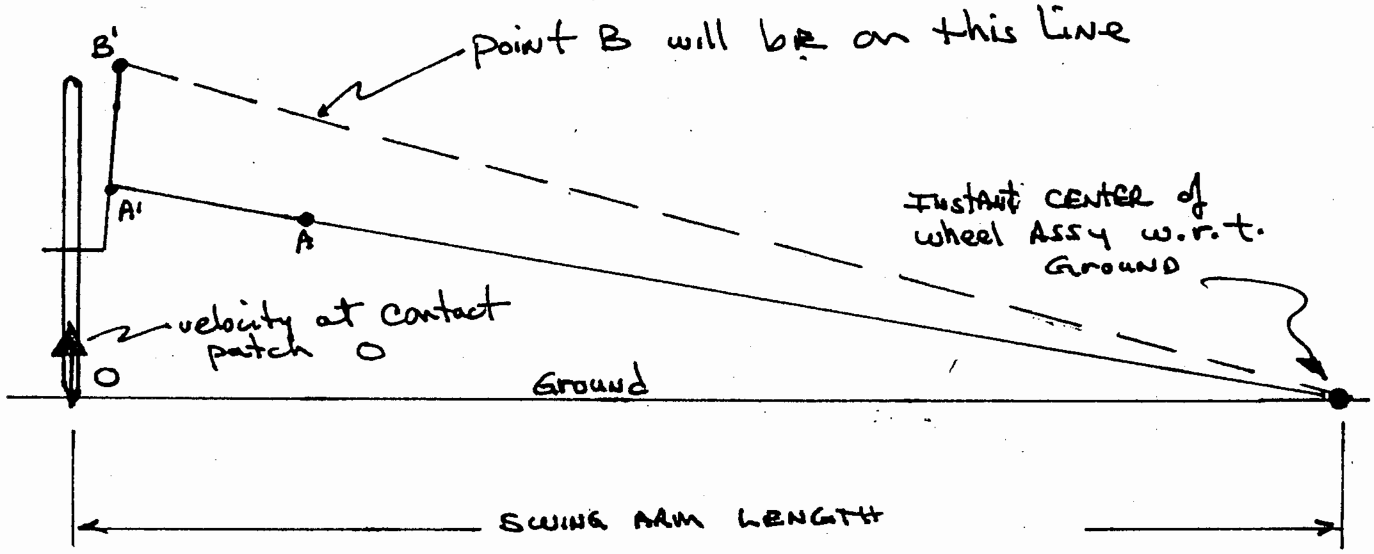
7. we need to allow clearances Δ_1 & Δ_2 of at least 0.06" OR 0.10" EACH

12-2-00 "STACK"



SCALE 1.000

Point B is found using two steps. First we find the line B'-B using the ground roll center idea:

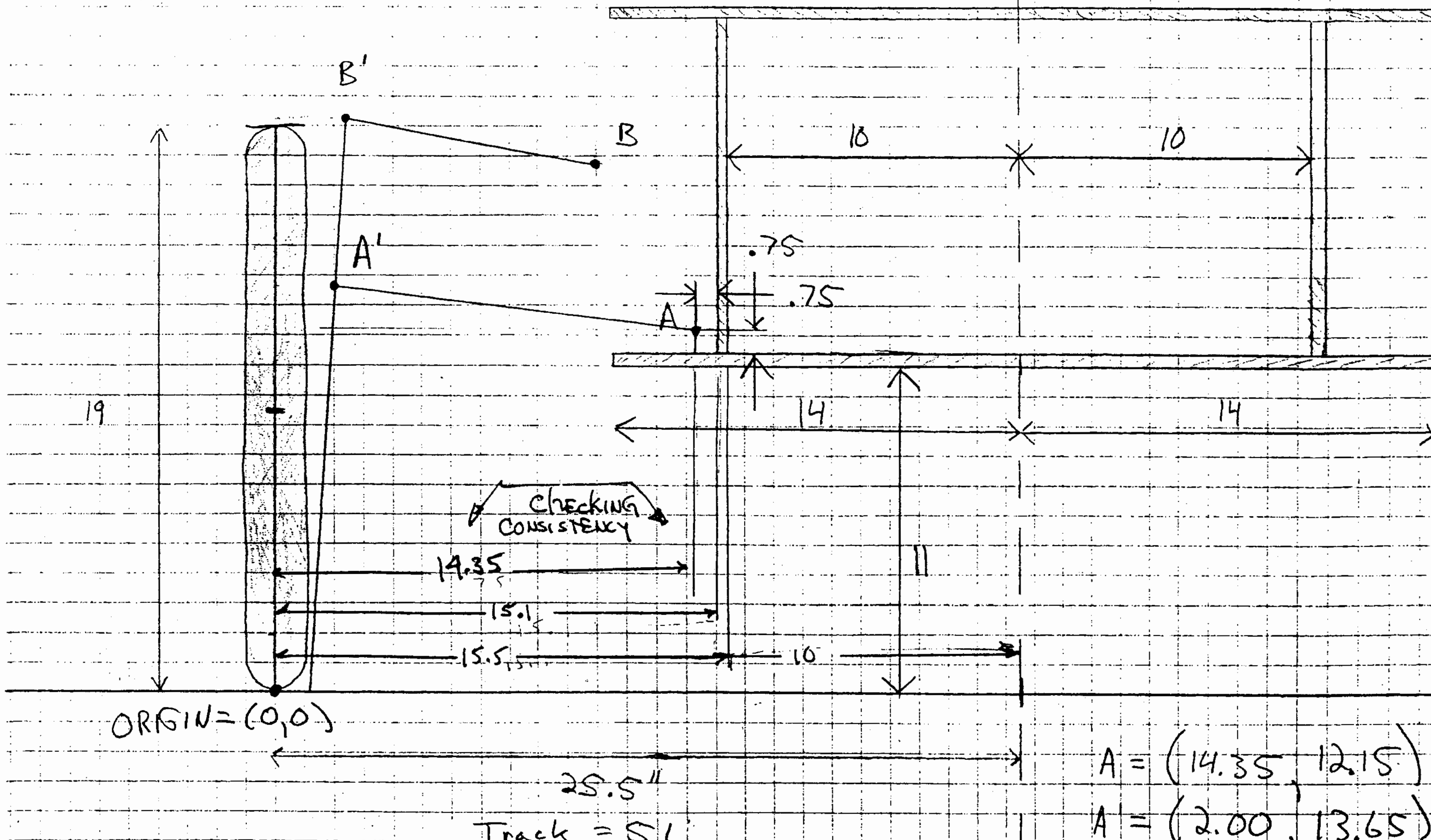


By placing point B on the dotted line, it will:

- Insure the Roll center is on the ground.
- Insure the instantaneous velocity at contact patch O is vertical around static position, which should nearly eliminate tire scrub (lateral motion) at O.

Second we locate B based upon a detailed analysis of scrub - which is introduced in Handout 7.

The next page shows the final layout for the Borealis front suspension



A = (14.35, 12.15)
A' = (2.00, 13.65)
B = (10.95, 17.75)
B' = (2.40, 19.25)

FINAL

67

TRACK = 51
RIDE HEIGHT = 11

Handouts 10 and 14 will discuss some of the details of the evolution of the BI and BII front uprights. The value of $X_A' = 2.0''$ and other dimensions are described.

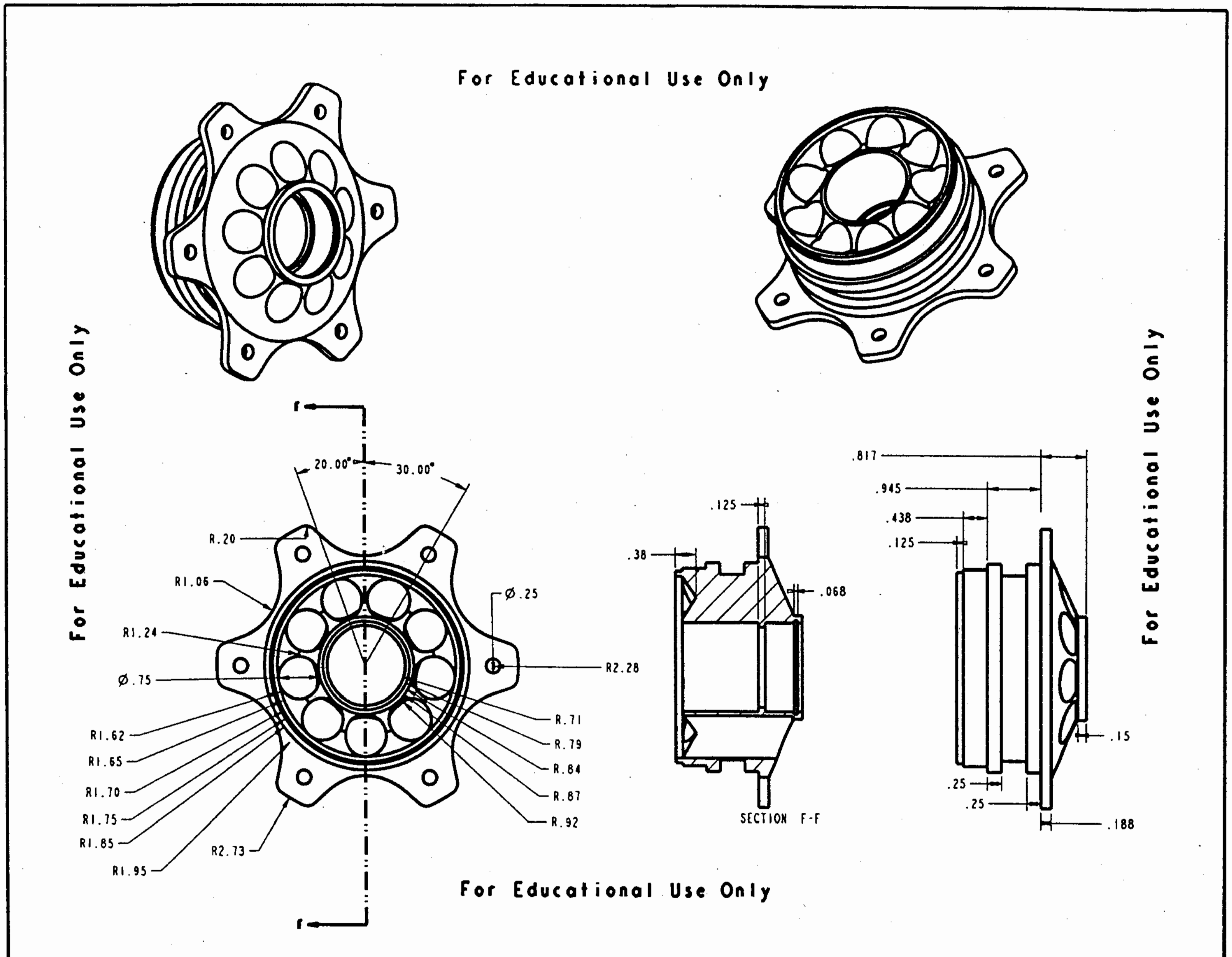
The Borealis I wheel hub was roughly sketched previously, and a more detailed drawing is on the following page. Note that the wheel drive pins also hold the brake disk, so brake torque is transferred directly from the wheel to the disk.

The last 3 pages show the axle/hub/brake assemblies from some other solarcars. The drawings are from G+H Craft, a maker of carbon fiber wheels.

Examine these drawings and note:

(1) axle diam & material
(2) Bearing spacing (you will need to estimate these)
(3) Bearing size & type

We can reverse-engineer these to estimate their ideas on loads & saftey factors.



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20.00°
30.00°
R.20
R1.06
R1.24
Ø.75
R1.62
R1.65
R1.70
R1.75
R1.85
R1.95
R2.73
Ø.25
R2.28
R.71
R.79
R.84
R.87
R.92
F
F
.125
.38
.068
SECTION F-F
.817
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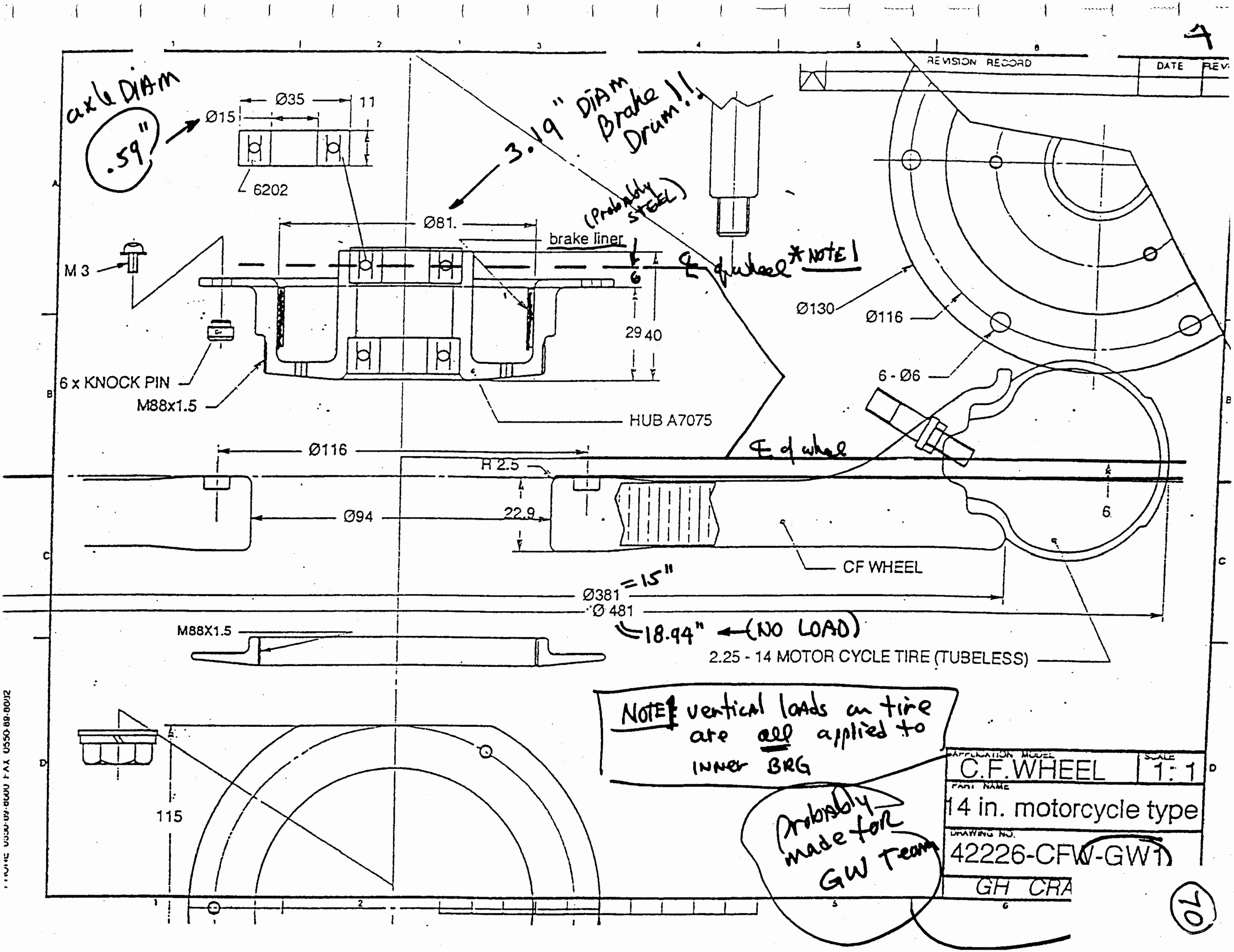
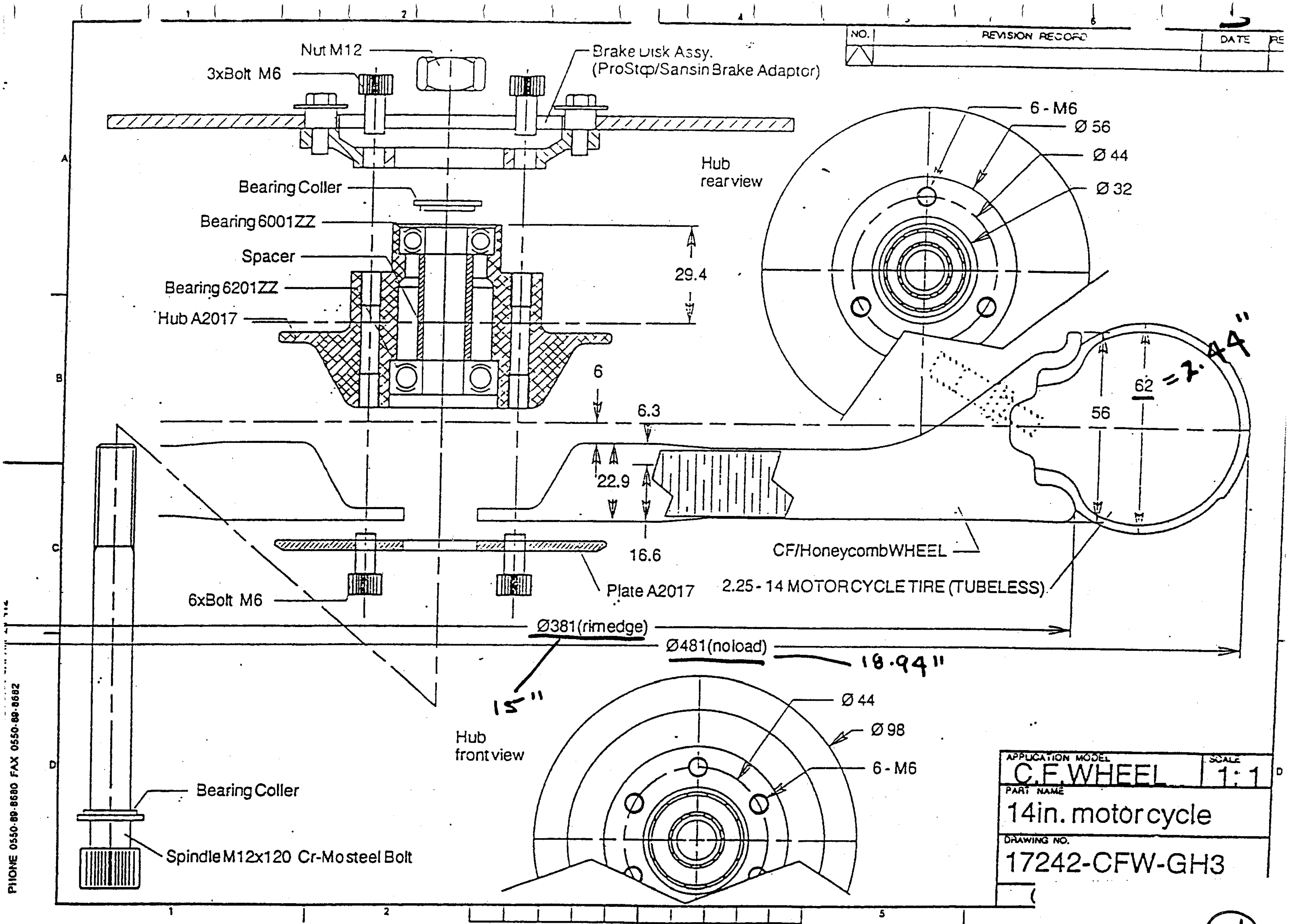
.125
.15
.25
.25
.188

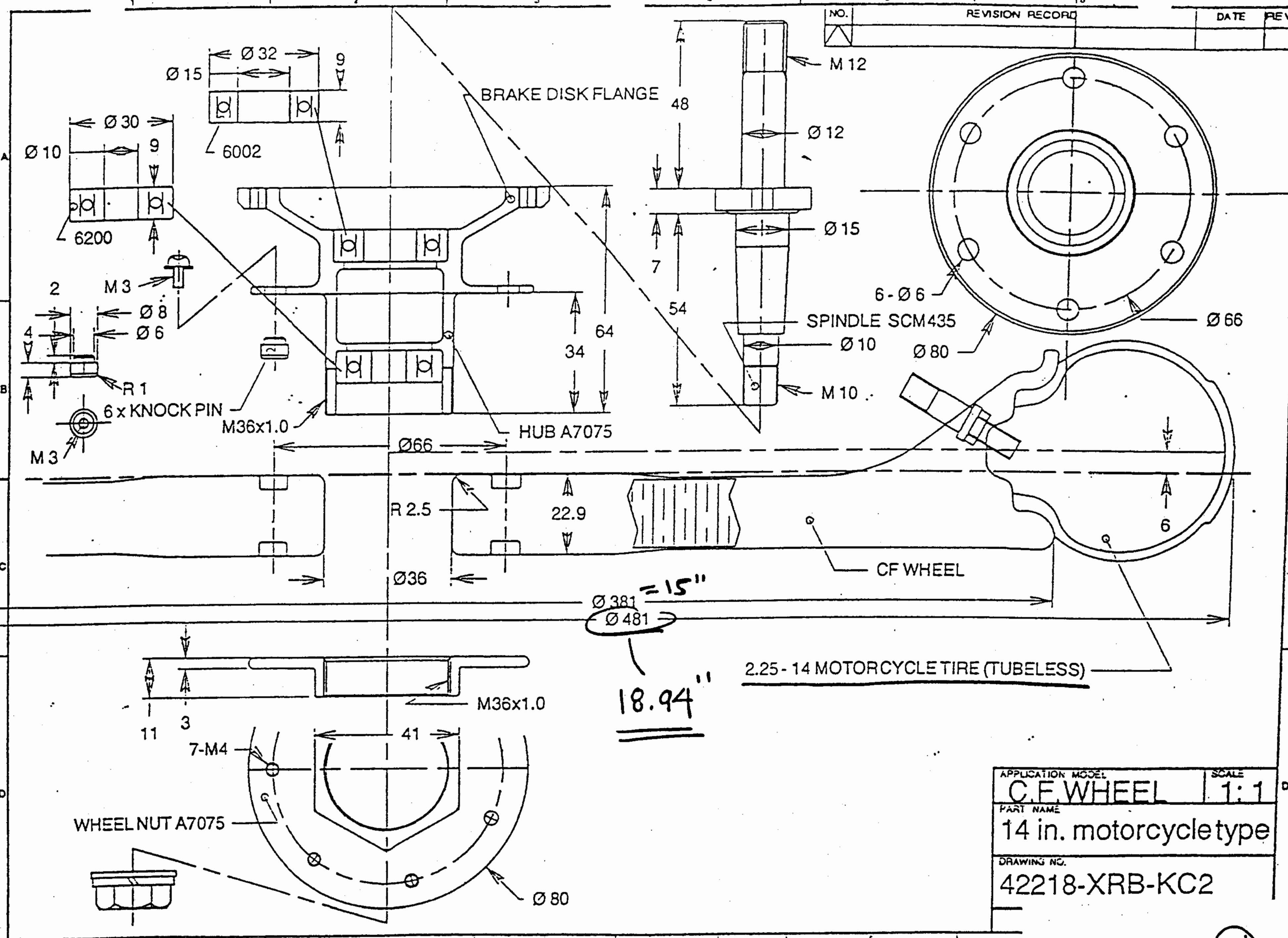


REVISION RECORD
DATE
axle DIAM
.59"
Ø15
Ø35
11
6202
3.19" DIAM Brake Drum!!
(Probably STEEL)
Ø81.
brake liner
M 3
6
29 40
℄ of wheel *NOTE!
6 x KNOCK PIN
M88x1.5
HUB A7075
Ø130
Ø116
6 - Ø6
℄ of wheel
Ø116
R 2.5
Ø94
22.9
6
CF WHEEL
Ø381 = 15"
Ø 481
= 18.94" ← (NO LOAD)
M88X1.5
2.25 - 14 MOTOR CYCLE TIRE (TUBELESS)
NOTE! vertical loads on tire are all applied to inner BRG
115
Probably made for GW Team
APPLICATION MODEL
C.F.WHEEL
SCALE
1:1
PART NAME
14 in. motorcycle type
DRAWING NO.
42226-CFW-GW1
GH CRA
70



APPLICATION MODEL: C.F.WHEEL	SCALE: 1:1
PART NAME: 14in. motorcycle	
DRAWING NO.: 17242-CFW-GH3	

71



APPLICATION MODEL: C.F.WHEEL

SCALE: 1:1

PART NAME: 14 in. motorcycle type

DRAWING NO.: 42218-XRB-KC2

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